OBSESSIONS AND CONVICTIONS
OF THE HUMAN INTELLECT

By the Same Author:

THE ENDLESS QUEST:
3000 Years of Science.

SCIENTIFIC METHOD:
Its Philosophic Basis, and its Modes of Application.

SCIENCE AND THEOLOGY:
Some Common Aims and Methods.
&c.

OBSESSIONS AND CONVICTIONS

OF THE HUMAN INTELLECT

BY

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DEDICATION

The author desires to inscribe this book to the masters and mistresses in the various types of Secondary Schools in Britain, in recognition of the work they are doing towards moulding aright the minds of the new generation.

PREFACE

This book touches upon certain fundamental questions of permanent human interest that have engaged the serious attention, during recent years, of the well-educated and more intelligent section of the younger generation. Many of the convictions of former days are admittedly dissolving rapidly in the light of new knowledge. Science and philosophy recognize the fact readily enough and are modifying their hypotheses accordingly. Political thought, both Right and Left, is perhaps more reluctant to abandon old formulas. So with theology: theologians tend, still in a large measure, to think of religion as something necessarily enshrined in the ancient dogmas of their own particular church. With all this the younger generation are showing much impatience and are insisting that any claim to infallibility or to any sort of exclusiveness must be submitted to examination. They argue that if, during the search for truth, shams are exposed, so much the more satisfactory.

For nearly half a century the author's professional work has brought him into close contact with young people of this kind, and he has been specially observant of their changing outlook during the period since the War.

It is not always realized what far-reaching changes have been made in the field of Secondary education during the last twenty years. In pre-War days, the ordinary work of a Sixth Form in any type of Secondary School, whether a Public School, or a Grammar School, or a modern Provided School, was roughly equivalent to what is now being done in the Fifth, viz. work for the School Certificate or Matricula-

tion examination; only a small handful of boys or girls did work of a more advanced kind, for instance, for University Scholarships, and this was usually associated with coaching or cramming rather than with teaching. Some twenty years ago, Sixth Form work was radically changed, and a much higher standard of attainments was exacted. The Form was divided into sections, each section being allotted a small group of subjects according to capacity and taste, perhaps classics, or modern languages, or history, or mathematics, or science, or small combinations of these, the course to extend normally over two years. At the end of that time a certain proportion of the pupils pass on to the University but a much larger proportion then leave school and enter upon some form of life occupation. Ordinarily, they will have taken a Higher Certificate examination in the subjects of their Sixth Form course, and they will be 18+ years of age.

Up to about the age of 16, school boys and girls, though something more than mere passive recipients of what is given to them by their teachers, are *in the main* merely receptive; they are too youthful, their outlook is still too childlike, their opinions are too crude, for their judgments to be acceptable. But under the discipline of the specialized work of the Sixth Form in which they are engaged during the next two years, there is a rapid change of outlook. The majority of Sixth Form teachers of the present day, no matter whether they are teachers of the ancient classics, or of modern languages, or of history, or of mathematics, or of science, are so well qualified, so capable, and so sane, that, during the two years in question, they transform their care-free 16-year-olds into well-informed, thoughtful, and severely critical 18-year-olds. These boys and girls receive a training in criticism, in analysis, in open-mindedness, in the resolutely impersonal treatment of personal problems, and they are already quite formidable opponents in debate. They have learnt to despise sentimentality, to be wary of enthusiasms, to be shy of superlatives, to scorn over-statement. Every Sixth Form teacher knows this—that if he has any opinion

which he wishes to conceal, his pupils may quite possibly become as familiar, and even indoctrinated, with it as with opinions which he has openly revealed to them: such insight is one of the inevitable results of the very training which he gives them. This intuitive analytical faculty, which is so rapidly increasing among the present younger generation, is not to be taken in by meretricious preaching of either priest or politician, no matter how sincere the preaching may be. *Produce your evidence* is now the insistent demand: your dogma—political, theological, scientific, or what not—*may* be right, but let us have the underlying bed-rock facts which support it, and we will draw the inferences for ourselves.—That is the present-day temper, and, whether we like it or not, it has come to stay.

Every July, well-trained Sixth Form boys and girls are now being turned out by the thousand, and their collective insistence on objective judgments is bound to have a far-reaching effect in future. Their characters have been moulded by their training in analysis and abstraction; and their minds are less and less likely to be the slaves of accidental associations, or to be the dupes of superficial appearances, or to be the passive recipients of opinions from authority. Sixth Form teachers no longer aim at creating those limp characters which to the last lean helplessly on authority and are fearful of intellectual freedom. On the contrary they teach their pupils both to be resolute of purpose in seeking the truth even when that means an intrepid defiance of their own pet prejudices, and loyally to accept the intellectual consequences of objective judgments, be these what they may. In the difficult years ahead of us, these young people are likely to prove, with riper experience, the dynamic strength as well as the restraining force of the country, not only in the conduct of affairs whether administrative, political, or commercial, but also in abstract thinking, in literary production, and in scientific research. Of course not all of them on leaving school are likely to be able to resist the influence of old loyalties. Here and there in this much-loved land of ours are still traces

of feudalism and mediævalism, and in such environments there is bound to be occasional intellectual backsliding.

It is believed that the book reflects, with some fidelity, the outlook of the intelligent section of the younger generation, say up to about the age of 35 or 40, whose views are still a long way from fossilization. The topics selected are those of special interest to such young people. The first chapter deals frankly with various forms of charlatanism, subjects which boys are never tired of lampooning. Then follow chapters on subjects which were of perennial interest for centuries, some of them eventually proving to be based on false premisses and all work done on them to be valueless, others proving to have some sort of potential value. The latter part of the book deals with topics which concern both the human intellect and the human feelings very closely, but subjects which, in the view of twentieth-century youth, must be submitted to impartial re-examination.

It was considered advisable to exclude politics from the scope of the book, but when the author invited questions, for his future readers, from a number of gifted young people who were known to him, most of them between the ages of 25 and 35, and left them an entirely free hand as to topic, a number of the questions proved to be of a political character and some of them seemed to be of sufficient interest to include in the Questionnaire at the end of the book.

> "At twenty-three
> We were the men who knew,
> Who could infallibly
> Distinguish false from true."
>
> * * * *
>
> "It's good to think infallibility
> Survives—that there will always be
> New men of twenty-three
> Who know they know."

This little gibe still applies to the great majority of the younger generation. But the increasing minority, for whom

this book is specially intended, shrink from asserting any sort of finality or from claiming any sort of infallibility. They are sensible enough to recognize that their opinions, no matter on what subject, are necessarily only provisional, and must always remain so, however often revised.

I have no desire to impose my own views on my readers. Rather I am anxious that the various authorities cited shall speak for themselves. But a letter which appeared in **The Times** from Professor Ernest Barker, on 11th Aug., 1937, so accurately reflects my own general views that I venture to quote part of it: "At the end of a life spent in teaching I am an educational anarchist so far as concerns the growth of true minds. When I find a true mind, I want to let it grow. Conscience used to make a coward of me, and I was once resolved to be a good tutor. Either I have lost my conscience, or it has acquired a finer edge. At any rate, I am now disposed to be very tender to the liberty of young minds. Their liberty includes their freedom from me. I insult them if I tell them first what to read—still more if I tell them just what is 'the right view'. They need their own intellectual adventures. If they ask me to go with them, I am proud to be asked: if they ask me questions, I will tell them what I think—and I will add that I am far from being sure about it."

That is also *my* confession, and I ask my readers to shrive me.

F. W. W.

ASPLEY HEATH,
August, 1937.

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"The simple believeth every word, but the prudent man looketh well to his going."

Proverbs, xiv. 15.

"Nam ceteri primum ante tenentur astricti, quam, quid esset optimum, iudicare potuerunt: deinde infirmissimo tempore aetatis aut obsecuti amico cuipiam, aut una alicuius, quem primum audierunt, oratione capti, de rebus incognitis iudicant, et, ad quamcumque sunt disciplinam quasi tempestate delati, ad eam, tamquam ad saxum, adhaerescunt."

Cicero, *Acad. Pri*, II. iii. 8.

"Generaliter autem pro suspecto habendum unicuique rerum naturam contemplanti quicquid intellectum suum potissimum capit et detinet; tantoque major adhibenda in hujusmodi placitis est cautio, ut intellectus servetur aequus et purus."

Bacon (Lord Verulam), *Nov. Org.*, lviii.

"New times demand new measures and new men.
The world advances, and in time outgrows the laws that in our father's days were best.
The time is ripe and overripe for change.
Then let it come; I have no dread of what is called for by the instinct of mankind."

James Russell Lowell.

CHAPTER I

Charlatanism and Chicane

1. Astrology

Astrology has been aptly called the illegitimate child of astronomy. At least as far back as early Babylonian times, men turned their attention to the movements of the sun, the moon, and the stars. They soon discovered that although the great majority of the stars maintained their relative positions, a few seemed to wander about, and eventually they noticed that the apparent paths of these wandering stars—the planets as they came to be called—as well as of the moon and of the sun himself were all contained in the same narrow highway amongst the fixed stars, a highway completely encircling the heavens. To this highway the name " Zodiac " was given, and the twelve fairly well differentiated star-groups or constellations in this highway were given special names, the symbols for which form the well known " signs " of the Zodiac.* Records of the movements of the sun, the moon and the planets were kept, and it was discovered that all were definitely periodic and therefore predictable. The possibility of such predictability, especially of eclipses of the sun and moon, put into the hands of the early priests a powerful weapon, and they were not slow to use it in order

* The Greeks did not invent the Zodiac. They borrowed it from the Chaldean astronomers who used the twelve signs at least 4000 years ago. And now it has just been discovered, on the basis of excavations in Sind, that the peoples of the Indus basin used the Zodiac thousands of years before the Chaldeans The Zodiac may have an antiquity of 10,000 years. The reader may refer to the researches of Father Heras, Professor of Indian History and Archæology at St. Francis Xavier's College.

to impress with their powers the simple-minded folk to whom they administered.

A knowledge of astronomy thus came to be used for a base purpose, and it was in this way that "astrology" originated. From the very first it was put forward as a scheme of divination: it was a directly God-given knowledge. Astrology must, however, be carefully differentiated from astronomy itself; the latter is a branch of true observational science; the former, even at its very best, is wild speculation.

It was a fact obvious to all and indisputable that man's life and happiness and not a little of his misery were traceable to phenomena of the heavens: for instance, the fertility of the soil depended upon the sun and upon rain; great damage was done by storms. From the apparent fickleness of the sun and of the weather, it was a short step to the fickleness of the moon, of the planets, and of the stars, and the conclusion was that all the great powers of the universe, friendly and unfriendly alike, had their seats in the heavens. The powers were personified and thus many of the gods were born. It was natural for priests of the baser sort to work out a complete scheme pretentiously showing an inevitability of connexion between phenomena observed in the heavens and occurrences on the earth. Since the motions of the heavenly bodies were invariable there must be, it was argued, a basic invariability amongst all the changing occurrences on the earth, all directed and controlled by the gods.

The scheme was childlike in its simplicity. The sun and the moon were given priority: the supremacy of the former and the brilliancy of the latter could not be questioned. The chief of the planets was obviously the great Jupiter, and Jovian attributes have always been synonymous with greatness of some kind. The most beautiful of the planets was Venus and was therefore heaven's chief goddess. The ruddy-looking Mars suggested blood and fire, and was therefore the war-god. And so forth. Fantastic figures, human, animal, and other, were outlined round prominent groups of stars, and these constellations were invested with great powers.

The actual positions of the planets at any particular time, especially at the time of a person's birth, were of great significance, the particular positions in the zodiac, and positions of conjunction and opposition having a deciding and decisive influence on the person's happiness, fame, fortune, and life. The zodiac was also regarded as a sort of prototype of the human body, the different parts of which

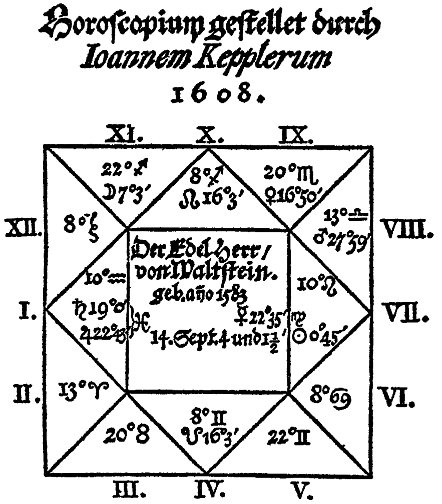

Fig 1 —Kepler's Horoscope of Field-Marshal Wallenstein

had their special sections of the zodiac itself. Thus, not only was the complete individual influenced by, and under the control of, a god, but every separate part of his body was under the care, benign or malignant, of some other god.

The modern astrologer, like his prototype down the ages, casts the "horoscope" of the person who consults him. This is a crude map of the heavens, perhaps a sort of cart-wheel with twelve spokes; perhaps a small square within a larger square, with the interspace between them divided into twelve triangles, the whole being well besprinkled

with meaningless symbols, purporting to represent the positions of the heavenly bodies, and therefore of the gods, at the person's hour of birth. Each of the twelve signs of the zodiac is credited with its own special characteristic and influence, but the destiny of the person is foretold by the planet or star which was in the "ascendant" at the time of his birth, that is, the planet or star which then happened to be peeping up over the eastern horizon. Once that particular Peeping Tom is identified, his intentions are known, and the destiny of the person under consideration lies revealed to the astrologer, who thereupon takes up his pen and writes. Oddly enough, the gods are always specially favourable to those who pay the astrologer a handsome fee.

One of the most famous astrologers of history was Michel de Notre Dame, or **Nostradamus** (1503–66). He wrote 1200 metrical stanzas of four lines each, a farrago of ambiguous prophecies. Occasionally, of course, one of his prophecies was fulfilled—even the most incompetent shot will bring down a bird sometimes—and at once the world rang with the praises of his uncanny knowledge of the future. It has always been characteristic of astrology that its prophecies are invariably clothed in ambiguous language, and the practitioners therefore stand to win anyway. Raphael's and Zadkiel's annual forecasts are modern examples.

Teachers of religion have always condemned the pretensions and doctrines of astrologers. In 1651, the then Bishop of Chichester issued a pamphlet to prove that the original inventor of astrology was the Devil himself. A much more effective attack on the cult was made by Swift in his famous "Predictions for the year 1708, by Isaac Bickerstaff, Esq.", an attack which was really its death blow.

But astrologers of sorts still survive and may be found during the summer at any seaside resort. Their dupes are most of them sentimental girls and neurotic women, who, however, seldom have any "belief" in astrology, one way or the other, though they are hopeful that the astrologer's blarney may perchance contain a grain of truth. Such people

are curiously obsessed with many surviving superstitions: watch their blanching faces if they spill the salt, if they find themselves thirteen at table, if they break a mirror, or if they pass under a ladder. But how they hate to be questioned about the nature of the bad-luck-producing agencies they seem to fear!

2. Phrenology

Phrenology, which is fifty centuries younger than astrology, was originally and more correctly called "Craniology". It is a system worked out by a German physician, Franz Joseph **Gall** (1758–1828), who assumed (1), that the mental powers of man may be analysed into a definite number of innate "faculties"; (2) that each of these has its seat in a particular region of the brain; (3) that each region is an accurate measure of the power of the faculty associated with it; (4) that the skull is so finely modelled to the surface of the brain that it is an exact copy of that surface; and (5) that this close correspondence between the outer surface of the skull and the surface of the brain therefore enables an observer to recognize by an examination of the surface of the head the relative sizes of the differentiated brain regions.

Gall marked out on his model of the head the assumed positions of 26 "organs", indicating them by enclosed areas more or less circular, with vacant interspaces. Two of his prominent followers, **Spurzheim** and **Combe**, closed up these interspaces and divided up the whole scalp into 35 coterminous patches.

Gall's system was purely empirical. He would select a number of men well known for, for example, their benevolence, examine their skulls, determine what cranial prominence they possessed most in common, and so arrive at the position of the "bump of benevolence". Then he would select a group of sentimental men, another of cautious men, another of pugnacious men, and so on—mathematicians, artists, musicians, orators, logicians, conscientious men,

acquisitive men, criminals, lunatics, and so forth. In this way he constructed his complete cranial chart. As a physician he could not have been entirely ignorant of the brain itself, but in those days the brain had not yet revealed any of its working secrets even unto the elect.

Gall's system has utterly failed to stand the test of time. The varying thicknesses of different skulls and of different parts of the same skull; the existence of the frontal sinus, sometimes of large size, the modification, sometimes in an extreme degree, of the relation of the brain surface to the skull surface during the process of ossification; features of the skull which are sometimes obviously a matter of chance: all these things are fatal objections to popular phrenology.

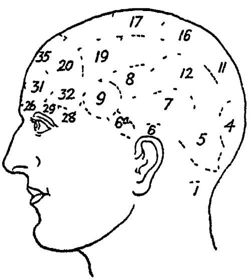

Fig 2 —The phrenologist's bump-chart

Attempts have been made to show that Gall's doctrines are in some measure confirmed by modern physiological and psychological research concerning cerebral localization. But cerebral localization is one thing, craniology quite another; and craniology is really all that the phrenologist stands for. The practical working of the system has become utterly discredited, and the so-called diagnoses of character are worthless.

That common phenomenon of holiday resorts, the "Professor" of phrenology, is usually quite unlettered and, as regards science, entirely untrained. He has probably never even seen a human brain, much less dissected one. He is almost certainly an impostor, but even if he has brought himself to believe that there is an element of truth in his system, his simple-mindedness does not make him any the less a social nuisance.

3. Palmistry

Palmistry, also called chiromancy (χείρ, hand, μαντεία, divination) is another predictive system, and, like astrology, is of great antiquity. It interprets the various irregularities of the skin of the hand as being associated with a person's character and powers as well as with the future events of his life. In the course of years a complete scheme has been worked out, and the rules are so simple that they only need mechanical application. A would-be palmist, like a would-be astrologer or phrenologist, need only purchase an instruction book for a few pence, master the whole scheme in an hour, cultivate a little suitable patter, assume an air of mystification, and then be ready for his dupes.

There is some divergence of practice amongst palmists, but the system at present in vogue is fairly uniform. Some importance is attached to the general shape of the hand, to the hardness and softness, dryness and moistness of the skin, but greatest importance is attached to a half-dozen well-marked lines showing the flexion folds of the skin, and to the swellings or "monticuli" isolated by these lines. To the relative sizes of these "little hills" are assigned definite correlations with characters, for instance, love, ambition, pride. The swellings on the palmar faces of the phalanges of the several fingers are also indicative of characters; for instance of reasoning power, order, truth, idealism. Then there is a large number of other distinguishing marks consisting of crosses, triangles, &c., to all of which have been assigned a specified interpretation.

The structure of the hand, with its bones, muscles, tendons, and skin, is quite familiar to the anatomist, and a wonderful work of nature it is. The hand is a perfect organ of prehension, and the folds of the skin are mostly the natural result of using the hand and fingers for grasping and holding. That this particular piece of nature's mechanism can have any

psychic, occult, or predictive significance is utterly fantastic. There is no more reason why the three main lines of the palm of the hand should be called the life, head, and heart lines than the lungs, liver and appendix lines. No rational hypothesis of correlation has ever been put forward; naturally so, for the whole cult is irrational and utterly contrary to common sense. The simpletons who profess a belief in palmistry violate the first principles of reasoning, for they have no facts whatever to go upon. That the palmist, like the astrologer and the phrenologist, hits the mark once now and then is a matter of mere chance and does not in any way affect the main issue. Even the four aces may be dealt out to the same person once or twice in his lifetime.

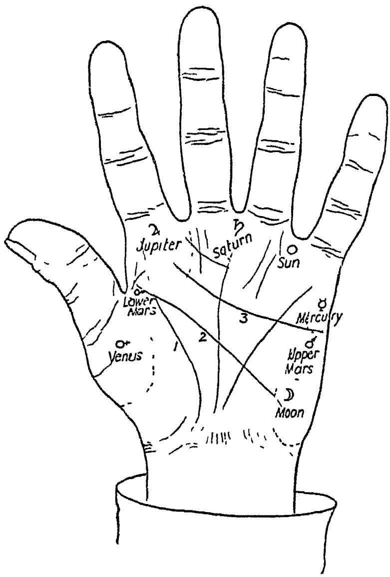

FIG. 3—Diagram showing mounts and principal lines of the hand

4. Magic

(1) By the untutored savage, primitive magic is still regarded as a practical means of ensuring success in any critical human undertaking. Magic and religion belong to the same department of human experience, but there is an essential difference: magic consists in man's attempted direct control of the forces of nature, while religion relies upon the propitiation of these and of other higher powers.

Magic is not merely a type of human *belief*; it is also a

human *art* in which dogma is always translated into action, and it is therefore a very practical affair. Its function is to bring rain to crops, game to the trap, to give stability and speed to the canoe, to ward off misfortune, to give skill in war, to win success in love. But though so distinctively a human art, it also involves a recognition of the supernatural and a belief that the normal operations of the forces of nature can be turned aside. In all savage communities the magic-man or magician is the one person who in point of authority and influence can be compared with the chief.

For the performance of any act of magic, the magician is hedged round by taboos, and his sympathetic emotional condition is fundamental. The outstanding parts of the magical act are two: the uttering of the **spell**, a formula handed down from immemorial antiquity, the slightest departure from the letter of which renders the whole act useless; and the performance of the **rite**, a set of actions the primary function of which is to convey the spell to the object which it is desired to affect. For instance, the sprinkling of water on the ground is a normal part of the magic of rain-making, and the destruction by fire of a waxen or other image of an enemy is part of the magic of bewitching the enemy with burning pains. Underlying all this there seems to be a sincere belief in a vague mysterious power, supernatural and immaterial, animating all things.

Sir James Frazer points out that an analysis of the principles of thought on which magic is based shows that there are two basic ideas: (1) like produces like, or an effect resembles its cause; (2) things which have once been in contact with each other continue to act on each other at a distance after the physical contact has been severed. But the magician's logic is always implicit, not explicit; his magic is always an art, never a science. He never *supplicates* a higher power.

There is a close analogy between the magical and the scientific conceptions of the world. In both of them the succession of events is perfectly regular and certain, being

determined by immutable laws; there are no elements of caprice or chance. But, as Sir James Frazer points out, the fatal flaw of magic lies not in its general assumption of a sequence of events determined by law but in its total misconception of the nature of the particular laws which govern that sequence. There is invariably a mistaken application of one or other of the two great fundamental laws of thought, namely, the association of ideas by similarity, and the association of ideas by contiguity in space and time. " It is true that magic often deals with spirits, which are personal agents of the kind assumed by religion, but it always treats them in the same fashion as it treats inanimate agents, that is it constrains or coerces instead of conciliating or propitiating them as religion would do."

Magic has been called " bastard science ", but the term is not a happy one. " Pseudo-science " is perhaps preferable, and " unscientific science " even more preferable. Underlying it is undoubtedly much rational technique and empirical knowledge, and at least to that extent it has a natural basis; and there is thus a sort of real science running side by side with the magic. The science is based on observation and experience; the magic is based on tradition and is impervious to the lessons of observation and experiment.

In spite of the illusory nature of its claims, magic posesses an undoubted value among primitive peoples. For instance, it regulates the times and seasons in agricultural work, it imposes useful taboos, it invests the labourers' daily work with a serious import, it enforces order and punctuality within the industry, the directing magician usually being a man possessing technical skill, persuasive powers, and force of character. Hollow its pretensions are, of course; the sky will not supply rain, animals will not come to the snare, a pestilence will not take itself away, a wilful maiden will not be cajoled, in response to spell and rite. Nevertheless to the untutored savage, magic remains a living reality.

It has been seriously asked if the whole is not just a hocus-pocus, and Tylor, no mean authority, roundly dubbed

it a monstrous farrago. The ritual is, however, so closely associated with the undoubted medical skill, political craft, knowledge of human weakness, and natural cunning of the practitioners, that it is almost impossible to overthrow its great traditional reputation As we have pointed out before, the *laws of chance* ensure success in a small proportion of cases. Added to this is the fact that the untutored mind is utterly unable to appreciate the value of negative evidence, especially when this is in opposition to the universal belief in an established institution. What matters a succession of failures if these are followed by a single chance success well boomed?

It is not merely ignorance of the laws of nature, it is also the general incapacity for inductive reasoning, that have led men to collect merely such facts as coincide with their preconceived opinions and to ignore those facts which are inconsistent with those opinions. By this method there is no supposition that cannot be defended. There is not an omen, however childish, that has not, in the infinite variety of events, been occasionally verified, and to minds which are under the influence of a superstitious imagination these occasional verifications far more than outweigh all the instances of error.

That the great majority of primitive communities are earnest believers in magic there is no doubt at all, and they certainly credit the practitioners amongst them with supernatural powers. And some of our anthropologists who know such communities intimately think that not a few of the practitioners themselves are also earnest believers; the belief is in their very bones, inherited from generations of ancestors. On the other hand, a few of the practitioners are unquestionably charlatans, battening on the credulity of the simple folk around them. They are not one whit better than the astrologer, the phrenologist, and the gipsy fortune-teller.

(2) Black magic, witchcraft, or sorcery, is an entirely different thing. It claims a power to produce effects by

supernatural means, and its practitioners are supposed to be associated with powers of evil. Until comparatively recent times, there was an almost universal belief in a personal Devil, a sort of arch-fiend attended by a multitude of minions and receiving from a jealous God vast numbers of "sinners" to be put to endless torture. The Devil was supposed to give witches and sorcerers special privileges. The superstition of a personal Devil is not even now altogether dead.

In England the legal definition of a witch is "a person who hath conference with the Devil to consult with him or to do some act". The witchcraft of the Middle Ages was a survival of paganism, a "religion" which preceded Christianity, and which had not wholly disappeared from rural districts even in the nineteenth century. The *pagani* were the people of the country villages of ancient Rome who clung to their ancient cults, and it was with them that the new Christianity fought its last fight. The old piety must have persisted in many a household even in Rome itself. It is not correct to think of paganism as "irreligious": it was anything but that, and to speak of it slightingly is to show a want of understanding. As always, when the new religion had gained sufficient strength, it ventured to try conclusions with the old, and when eventually the new was backed up by the civil law the old was bound to be suppressed; the old family piety was ignored, but the associated superstitions were dragged into the light. It is well known that in Renaissance and later times the ministers of some of the newer Christian churches were as zealous as the priests of Rome in hunting down and bringing to trial and death persons suspected of witchcraft. Doubtless some of the so-called witches had been guilty of reprehensible practices, but the great majority were the victims of malevolent rumour and petty spite. We shall return to this subject in a later chapter.

5. Quackery

Originally a "charlatan" was one who pattered to a crowd while selling his wares (Ital. *ciarlare*, to chatter), like a cheap-jack or quack-doctor, the term "quack" being similarly derived, onomatopoetically, from the noise made by a duck. A charlatan or a quack is invariably an impostor, a person who pretends to have some special skill or knowledge.

The medical quack is a social danger, for he pretends to be able to cure such diseases as cancer, chronic rheumatism, and chronic asthma, and yet he knows, just as well as the qualified medical man, that for these diseases no cures have been discovered. For cancer, for example, he still uses the same corrosives and other compounds that have been tried over and over again and have been demonstrated to be utterly useless and even dangerous. For not a few diseases he prescribes electrical treatment, impressing his patients with a pseudo-scientific jargon and selling them expensive but useless appliances. He *knows* he is an impostor; he hasn't the shadow of a belief in the efficacy of his "cures". He knows nothing of diagnosis, but he does not scruple to expose his dupes to the indignity of a clinical examination.

The despairing sufferer who has been honestly told by the orthodox practitioner that his case is beyond medical skill is naturally anxious to leave no stone unturned to get rid of his trouble and feels that there may be "something" in the quack's plausible statements. And so the quack thrives. That the newspaper press should accept the advertisements of such impostors is to be deplored.

It is not easy to decide whether osteopaths should be included in the category of quacks. They deny the principles of orthodox medicine and advance the theory that every disease is due to some abnormality of structure or tissue, and can be cured by suitable manipulation. They make

some attempt to defend their views but under expert cross-examination invariably break down hopelessly. Not all of them are charlatans; some appear to have a genuine belief in the theory they advance. But their medical training is invariably superficial and their knowledge of biology, physiology, and disease is absurdly inadequate They are no better qualified to set up as medical practitioners than are ordinary mechanics to undertake to build bridges over the Thames.

Manufacturers of patent medicines hardly deserve to be branded as quacks, though their advertisements are usually boastful and full of exaggeration. Such medicines have been analysed by the British Medical Association and the results, together with the cost, have been published; in fact, the manufacturers' own formula now usually appears on the packages sold. In all cases the profits are enormous, and great fortunes are made out of a gullible public. Most of the medicines are harmless, and a few are useful, but all are best avoided unless recommended by a qualified medical man.

6. Charlatanism on the Grand Scale: Cagliostro

Charlatanism on the grand scale is personified in Giuseppe Balsamo, better known by his assumed name of **Count Cagliostro** (1743–95), who was born at Palermo. Plausible in address, persuasive of speech, an apt scholar, of unbounded assurance, brazenly impudent, an arrant knave, equally at home in a street brawl or a court intrigue, he took all chicanery for his province, for there was no species of it of which he was not a master—astrology, spiritism, miraculous cures, legerdemain, alchemy, magic, and so on. He was a thief, a forger, an arch-swindler, and a murderer. A short squat figure, bull-necked, healthy, very active, and of great strength, he gave out that he had been present at the Crucifixion seventeen centuries before, and had lived ever since, never changing his appearance; actually he was then 35. He married a beautiful Roman girl of 20 who, as

unscrupulous as himself, told the world she was then 60 and had a son of 40. No wonder they were able to make a fortune from the sale of their so-called elixir of perpetual youth.

The most interesting account we have of Cagliostro appears in Carlyle's miscellanies. Carlyle was a master of strong language which he never used to greater purpose than when describing this arch-villain, "the most perfect scoundrel that in these latter ages has marked the world's history". A genuine hero always attracted Carlyle, so did "a knave of the first water". But he could not tolerate a "half knave", who is "wholly despicable, spends his whole life in plastering together the True and the False and therefore manufacturing the plausible, a mere moral hybrid, a deceptive nonentity". But Cagliostro? no half knave, that. Carlyle admitted that Baron Munchausen was a celebrated liar, but compared with Cagliostro, Munchausen was a liar only "from the teeth outwards". Cagliostro was the liar of liars and the knave of knaves; "by profession healer of diseases, abolisher of wrinkles, spirit-summoner, gold-cook, Grand Cophta, prophet, priest, thaumaturgic moralist and swindler; really a Liar of the first magnitude, thoroughfaced in all provinces of lying, the King of Liars; one who lied not in act and word only but continually in thought, word, and act, and, so to speak, lived wholly in an element of lying. There was no type of rascality and scoundrelism of which he was not a master." But though such an arch-rogue, what a genius!

Cagliostro was the true representative of the half-century in which he lived, an age of quacks and impostors, of vampires and swindlers, of social decay. He had a host of imitators, most of whom were far more brazen and unscrupulous than the modern practitioners of astrology, phrenology, palmistry, and quackery. May it therefore be argued that morally they were more reprehensible? They did not even trouble to make the pretence that the practices they preached had a rational basis and were worthy of serious belief, and the

multitudes of their patrons must have known that they were really villains. If some form of knavery is practised in an expensively furnished room by a well-dressed person with a plausible manner, can it be said to be less immoral than the same thing blatantly practised in the open market-place by an impudent Cagliostro? And who are the greater simpletons, the dupes in the former case or those in the latter? In what sense can it be said that such simpletons ever become *converted* to a belief in the wily knaves they have listened to?

CHAPTER II

Alchemy (i):

(α) The Philosophers' Stone
(β) The Elixir of Life

1. The Alchemists: their Materia Prima

There is considerable doubt about the origin of the term "alchemy", though it is probably derived from the Arabic *alkimia*, *al* representing the definite article *the*, and *kimia* signifying the preparation of silver and gold. Joannes Antiochenus says that Diocletian burned the books of the Egyptians concerning the transmutation of silver and gold; the term has therefore been identified with χημία, the Greek form of *Khmi*, the native name of Egypt, literally "black earth". Another suggestion is that χημία, is probably a form of χυμεία, an infusion, itself derived from χυμός, juice, especially the juice of plants; thus alchemy would originally signify the act of extracting juice from plants for medicinal purposes. Be the origin of the term what it may, alchemy usually signifies the chemistry of the Middle Ages and of Renaissance times. It is not, as is sometimes thought, always synonymous with quackery and roguery, for it includes all the serious research and discoveries of the early chemists. There was, however, a great deal of quackery and roguery associated with it, and it is with that side of it that this chapter mainly deals.

The still prevalent opinion that alchemy originated in the work of mediæval metallurgists is not correct. It is of much greater antiquity, for it is certain that both the Chinese and the Hindoos engaged in the search of a means for prolonging

human life, and they must therefore have practised some sort of primitive chemistry. The further search for a means of transmuting "base" metals into gold probably arose a little later. Right from the first, however, the alchemists conducted their operations in great secrecy, and the scanty records they kept are so enshrouded in an obscure symbolism that interpretation is often impossible.

It is definitely on record that in Western Europe, and especially in this country, alchemists were at work at least as early as the thirteenth century. During this century, that is towards the close of the period of Scholasticism and just before the dawn of the Renaissance, Europe produced three intellectual giants, **Albertus Magnus** (1206–80), a German of great erudition, belonging to the Dominican Order of Friars; his still more famous pupil **Thomas Aquinas** (1226–74), an Italian, also of the Dominican Order, and **Roger Bacon** (1214–94) an Englishman, of the Franciscan Order. Thomas Aquinas does not appear to have interested himself greatly in alchemy, though he was recognized as an alchemist of the mystical type; his belief in the transmutation of metals he probably accepted from his master, Albertus Magnus. We shall refer in a future chapter to the fundamental distinction he drew between reason and faith, the former being based on sense-data, the latter on revelation and authority. But Albertus Magnus wrote an Encyclopædia, to enable his brother Dominicans to understand the writings of Aristotle. In this Encyclopædia he showed himself keenly interested in science, but his science was not derived from experiment—he probably never handled a crucible or retort in his life—but from books, eked out with words and logic of his own; and as a man of science he therefore failed, for the same reason that Aristotle had failed. Moreover, he did not possess the critical insight of his pupil Aquinas. He did, however, consider such experimental facts as were available from the work of practical alchemists, and though he could not have understood their inner significance, it may have been partly from such facts that he undoubtedly brought

himself to believe in the transmutation of metals. No one had yet produced gold from a base metal, but that did not matter; he, Albertus, had reasoned things out, and his reasoning was rigorously logical. That his premisses might be inadequate and unreliable did not occur to him. The faith that had come to him was not to be questioned.

The Englishman, Roger Bacon, was the successful pioneer of experimental investigation, but, apparently like Francis Bacon three centuries later, he did not himself personally put into practice the sound methods he had thought out and advocated. He was certainly the champion of unfettered inquiry, and it is an extraordinary thing that such a man should have had any lingering belief in the philosophers' stone, and it is still more extraordinary that he did not try to settle the matter once for all by putting it to a definitely acceptable experimental test.

Two of the most famous working alchemists of the thirteenth century are worthy of mention. (1) **Raymond Lully** (1235–1315) a Spaniard who was persuaded by the Abbot of Westminster to come to London and to work in a laboratory specially fitted up in one of the Abbey cells; (2) **Arnaldus de Villa Nova** (1235–1313), a Frenchman, the confidant of kings and popes, who considered a solution of gold to be the most perfect medicine, which therefore was believed for a time to be the true Elixir of Life.

In these early days, the ranks of the alchemists were recruited from men of various classes. Albertus Magnus says, "I find abbots, superiors, canons, physicians, and many unskilled folk who practise the art". But many of these were mystics—members of religious orders—who believed that the transmutation of one thing into another could be effected only by spiritual means acting on the spirit of the thing itself. They were not working alchemists—laboratory workers—but men who had irrationally accepted the belief from others who were of the same general way of thinking as themselves. They have been described as philosopher-alchemists. But a race of *pseudo*-alchemists also

sprang up, unskilled and ignorant rogues who sought to trade on the credulity of the multitude. They were neither working alchemists nor philosopher-alchemists: they were charlatans. It was an age when human credulity was easily impressed.

The basic hypothesis of alchemy was that all substances are ultimately composed of an elemental matter, the *materia prima*, and that therefore it ought to be possible to devise a means for discovering it. The *materia prima* was at first identified with mercury, not ordinary mercury but "philosophers' mercury", that is, mercury freed from the four Aristotelian elements, earth, air, fire, and water, or rather from the qualities which these represent. The *materia prima* thus obtained had to be treated with sulphur which was supposed to confer upon it the desired qualities that were missing. This sulphur again was not ordinary sulphur but some principle derived from it. As a definite sequence of laboratory processes the whole scheme is so obscure as to be incomprehensible, but the general intention underlying the main hypothesis seems to have been that the discovery of the *materia prima* was an essential preliminary to the discovery of the Philosophers' Stone and the Elixir of Life. The mediæval alchemists strove in every way to discover the so-called Philosophers' Stone, and the most incredible substances were from time to time used as possible raw material. Once found, the Philosophers' Stone was to be used as a "medicine" for transmuting base metals, these base metals, that is the common metals, being looked upon as noble metals suffering from some kind of sickness which could be cured.

2. The Philosophers' Stone: the Elixir of Life

The Philosophers' Stone was always a mysterious and elusive thing, though some alchemists claimed to have discovered the secret of it. One alchemist tells us that it was called a stone "not because it resembled a stone but because,

like a stone, it successfully resists fire ". Its appearance was " that of a very fine powder, impalpable to the touch, sweet to the taste, fragrant to the smell, in potency a most penetrative spirit, apparently dry and yet unctuous, and easily capable of tingeing a plate of metal. If we say its nature is spiritual, it would be no more than the truth; if we described it as corporeal, the expression would be equally correct."

Its colour has been variously described as red, black, white, yellow, blue, green. Detailed descriptions of it continued to be given for hundreds of years. In the sixteenth century, Paracelsus described it as a solid body like a ruby, transparent and flexible, and in the seventeenth century Helmont described it as " yellow, the colour of saffron, in the form of a heavy powder, with a brilliancy like glow ". And Paracelsus and Helmont were practical chemists!

The Philosophers' Stone had other names—" the Great Elixir ", " the Magisterium " (masterpiece), " the Quintessence ". Sometimes the Philosophers' Stone and the Elixir of Life were regarded as two different things, sometimes as merely different names for the same thing. In Salmon's *Bibliothèque des Philosophes Chimiques* it is defined as " a universal medicine for all imperfect metals ". But in course of time the alchemists became more and more extravagant in their visions. They made their wonderful stone not only transmute metals but make precious stones, prolong life, cure diseases, and control spirits. Examples of such extravagances abound in the works of authorities on alchemy. We will quote just one: it is taken from McGowan's translation of **von Mayer's** *History of Chemistry*:

" In the Middle Ages there was an almost universal belief in the transmutation of metals by means of the Philosophers' Stone. To it, the greatest miracles were ascribed. **Roger Bacon** himself does not hesitate to say that it was able to transform a million times its weight of base metal into gold. (*millies million et ultra.*) Others, e.g. **Arnaldus de Villa Nova**, were more modest in their estimate of its powers,

stating that it could convert into gold one hundred times its weight of mercury. Others, again, surpassed even Bacon, as the following passage from the *Testamentum Novissimum* ascribed to **Lully**, proves: 'Take of this precious medicine a small piece, as large as a bean. Throw it upon a thousand ounces of mercury, and this will be changed into a red powder. Put one ounce of the latter upon one thousand ounces of mercury, which will thereby be transformed into a red powder. Of this again, an ounce thrown upon a thousand ounces of mercury will convert it entirely into medicine. Throw an ounce of this on a thousand ounces of fresh mercury, and it will likewise turn into medicine. Of this last medicine, throw once more an ounce upon a thousand ounces of mercury, and this will be entirely changed into gold, which is better than gold from the mines.' "—Nonsense of this kind would be an insult to the intelligence of a modern Fourth Form boy, and yet it was put forward, not by a philosopher-alchemist ignorant of laboratory processes but by the principal practising alchemist in this country at the time, a man who had his laboratory in Westminster Abbey itself, the Abbot being his patron.

But what was the *formula* for this amazing "medicine", this wonderful "stone"? The pretence of writing it out was often made, but always in a jargon utterly incomprehensible. Needless to say, the stone was never actually produced, and the whole thing was a colossal fraud. The old books teem with recipes, but when they can be interpreted they are found to be mostly recipes for common-place metallurgical processes. The transmutation of common metals into gold was, of course, never effected.

As already stated, the "Elixir of Life" was identified by some as the Philosophers' Stone itself; by others it is described as a solution of the stone in spirits of wine; by others as a solution of gold. It became a common belief that by taking the Elixir a man might prolong his life to a thousand years. Others declared that it not only gave perpetual youth but also a vast increase of knowledge and wisdom.

Although concoctions, vile and worthless, purporting to be the Elixir of Life were sold for centuries, the claim of alchemy that appealed most strongly to most people was the artificial making of gold. To the avaricious man and to the needy prince the claim was irresistible. In the fifteenth and sixteenth centuries an alchemist was to be found in nearly every court in Europe. **Rudolph II** (1552–1612), Emperor of Germany and King of Bohemia and of Hungary, the famous patron of Tycho Brahé and Kepler, did much to encourage the practice of alchemy at Prague.

Naturally it always happened that the court alchemist inevitably failed to deliver the gold he had so rashly promised, and in those days royal vengeance was apt to be swift and merciless. A certain **Marie Zeigler** was roasted alive by Duke **Julius of Brunswick** in 1595; about the same time our own **Queen Elizabeth**, more merciful than her father, merely committed **Cornelius de Lannoy** to perpetual imprisonment in the Tower; in 1709 the then King of Prussia hanged the Italian **Caetano**, grimly ordering the gallows first to be gilded with Dutch metal. It is said that **Frederick of Würzburg** maintained a special gallows which he employed solely for the purpose of hanging alchemists.

One of the last serious pretenders to transmutation was a **James Price** (or **Higginbottom**), who at the age of 29 had been elected a Fellow of the Royal Society. He seems to have thought that he had at last discovered the great secret, and he announced that he had made a white powder which would convert fifty times its own weight of mercury into silver, and a red powder which would convert sixty times its own weight of mercury into gold; and he maintained that qualified assayers had pronounced genuine the silver and gold he had thus produced artificially. The Royal Society, then as now jealous of its reputation, insisted on a demonstration before experts, but Price, knowing that his demonstration was bound to fail, committed suicide in the laboratory where the experts had assembled to watch him at work. He was only 31. He must have *known* he would

be found out. Had he at one time really *believed* in the transmutation of metals? If so, had he merely caught the contagion of the belief from the ignorant multitude who had inherited the belief from previous ignorant multitudes? In any case, why did he not, trained man of science as he was, put his belief to decisive experimental test before vaunting it to the world? Having once made the boast, did he fear to face the inevitable exposure? He seems to have been a curious admixture of credulity, bombast, vanity, and craven-heartedness.

3. Alchemists in Literature

During the sixteenth and seventeenth centuries, chemistry was gradually placed on an increasingly scientific basis, and alchemy, in its less reputable sense, therefore naturally fell more and more into the hands of charlatans, many of whom soon found that by pretending to make gold for the gullible they were able to make plenty of real gold for themselves. In the literature of the period there is frequent reference to the decay and degradation of alchemy. Rare **Ben Jonson** (1573–1637), in *The Alchemist*, makes Sir Epicure Mammon say:

> " Unto thee I speak it first: Be rich.
> This night I'll change
> All that is metal in thy house to gold;
> And early in the morning will I send
> To all the plumbers and the pewterers,
> And buy their tin and lead up; and to Lothbury
> For all the copper.
> But when you see the effects of the great medicine
> Of which one part projected on a hundred
> Of Mercury, or Venus, or the Moon
> Shall turn it to as many of the Suns,
> Nay to a thousand, so *ad infinitum*.
> He that has once the flour of the sun,
> The perfect Ruby, which we call Elixir,
> Not only can do that, but by its virtue

Can confer valour, victory, love, long life,
To whom he will. In eight and twenty days
I'll make an old man of four score a child,
Restore his years, renew him like an eagle,
By taking once a week, on a knife's point,
The quantity of a grain of mustard of it."

Samuel Butler (1612–80), in his *Hudibras*, really a pungent satire on the Puritans, says of the Knight's Squire, Ralph:

" He could deep mysteries unriddle
As easily as thread a needle.
For mystic learning wondrous able
In magic, talisman, and cabal
Whose primitive tradition reaches
As far as Adam's first green breeches.
He'd extract numbers out of matter,
And keep them in a glass, like water,
Of sovereign power to make men wise;
For, dropped in blear thick-sighted eyes,
They'd make them see in darkest night,
Like owls, though purblind to the light.
By help of these, as he professed,
He had First matter seen undressed:
He took her naked, all alone,
Before one rag of form was on."

The story of the French potter, **Bernard Palissy** (1510–89), who spent many years of his life in an attempt to find the secret of Chinese porcelain, thereby reducing himself to penury—he tore up the very floor-boards of his house in order to feed his furnaces—typifies the sort of life led by many alchemists in their laboratories during their fruitless search for the Philosophers' Stone. Literature abounds in stories of disappointed alchemists. One of the best-known is **Balzac's** *La Recherche de l'Absolu*, in which **Balthazar Claes**, a Belgian of great wealth, who in a vain lifelong search for what Balzac appropriately calls the Absolute, spent the entire fortune of himself and family on his laboratory work. The whole book is worth reading, for it describes with

great vividness the growing disappointment and ultimate despair of a great man. We give a few short extracts:

Early on: "Deep thoughts seemed to be visibly expressed in the pale face with its deeply carved wrinkles, to have scarred the furrows on a brow like that of some old king full of cares, and to shine forth most clearly from the brilliant eyes; the fire in these seemed to be fed by the temperate life which is the result of the tyrannous description of great ideas. They were deeply set and surrounded by dark circles, which seemed to tell of long vigils and of terrible prostration of mind due to reiterated disappointments."

Later: "His large hands were soiled; there were jet-black lines at the tips of his long finger-nails. There was an air of slovenliness about him. His shoes were seldom cleaned, and the laces were broken or missing. His black cloth breeches were covered with stains, buttons were lacking on his waistcoat, his cravat was askew, and everything about him down to the smallest trifle combined to produce an uncouth effect."

Later still: "The outlines of his features were obliterated by wrinkles; his fixed gaze, the desperate look in his eyes, and his restless uneasiness seemed to be symptoms of insanity. A sudden gleam of hope would give him the look of a monomaniac; an access of impatience that he could not guess the great secret which flitted before him but eluded his grasp like a will-o'-the-wisp, would blaze out into impotent anger and frenzy. But every phase of frenzy seemed to melt into the dull melancholy of the idiot."

And again: "The house had been stripped completely. Everything that could bring in a few pence, even the kitchen utensils, had been sold."

Lastly: "The old man was struggling against the paralysis that bound his limbs. He made incredible efforts to speak; great drops of perspiration broke out on his forehead. Suddenly a breath of inspiration passed over his face. In frenzy he raised a clenched hand and uttering Archimedes' cry, *Eureka*, he fell back, and died with a despairing moan. Too late had the secret of the Philosophers' Stone been revealed to him."

CLAES IN HIS ATTIC LABORATORY

Claes We will try a new experiment.

Marguerite Never mind the experiments now, Father Here is a demand for 100,000 francs, and we have not a farthing —I will not have it, I will combat your madness

Claes Madness! cried Balthazar, *Madness!*

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CHAPTER III

Alchemy (ii):

(γ) The Transmutation of Metals

1. The Authority of Plato and Aristotle

It is impossible to understand the slow progress made by chemistry during so many centuries, unless we trace to its source the alchemist's main obsession as to the possibility of transmuting common metals into gold. This source undoubtedly had its ultimate origin in the curiously reverential faith with which the opinions and the methods of the ancient Greek philosophers were almost universally held. For many centuries it was looked upon as something of an impiety to question any statement that had been made by Plato or his pupil Aristotle. The Italian professors were furious with young Galileo when he dared to put to an experimental test, and thereby to prove wrong, Aristotle's dictum concerning falling bodies. This curious reverential faith in Aristotle survives in some measure to the present day. Even since the Great War one of our most distinguished philosophers —he has only recently passed away—strongly protested in the newspaper press against Einstein's revolutionary notions concerning space and time. Had not Aristotle explained the nature of space once for all? then there was nothing more to be said.

The Aristotelians devoted a good deal of thought to the constitution of matter, and they worked out a kind of theory, logical and complete as far as it went. Aristotle had taught that there were four " elements " of which all things consist.

He did not, however, use the term "element" in the modern sense, that is, he did not imply that all kinds of matter can be subdivided or simplified into four constituents. Rather he intended the term element to signify a fundamental *property*. The four were:

1. *Fire*, the property of dryness and heat.
2. *Air* (or vapour), the property of wetness and heat, or gaseousness.
3. *Water*, the property of wetness and cold.
4. *Earth*, the property of dryness and cold, or of solidity.

Everything was supposed to contain one or more of these fundamental constituents, which imparted to it their properties.

But the great work of classical times which attempts to give us a general review of physical science, as it was then apprehended or as far as philosophers then claimed to apprehend it, was Plato's *Timaeus*. The following three quotations must suffice to illustrate the text:

1. "Now that which is created is of necessity corporeal, and also visible and tangible. And nothing is visible where there is no fire, or tangible which is not solid, and nothing is solid without earth. Wherefore also, God in the beginning of creation made the body of the universe to consist of *fire* and *earth*. But two things cannot be held together without a third; they must have some bond of union. And the fairest bond is that which most completely fuses and is fused into the things which are bound; and proportion is best adapted to effect such a fusion. For whenever in three numbers, or magnitudes or powers of any kind, there is a mean, and the mean is to the last term what the first term is to the mean; and again when the mean is to the first term as the last term is to the mean, then the mean becoming first and last, and the first and last both becoming means, all things will of necessity come to be the same, and being the same with one another will all be one. If the universal frame had been created a surface only and having no depth, one

mean would have sufficed to bind together itself and the other terms; but now, as the world must be solid, and solid bodies are always compacted not by one mean but by two, God placed *water* and *air* in the mean between fire and earth, and made them to have the same proportion so far as was possible (as fire is to air so is air to water, and as air is to water so is water to earth), and thus he bound and put together a visible and palpable heaven. And for these reasons, and out of such elements which are in number *four*, the body of the world was created in harmony and proportion."

2. "How and in what way can we reason, and at what probable conclusion can we arrive?—In the first place, that which we are now calling water, when condensed becomes stone and earth, as our sight seems to show us; and this same element when melted and dispersed, passes into vapour and air. Air, again, when burnt up, becomes fire; and again fire, when condensed and extinguished, passes once more into the form of air; and once more, air, when collected and condensed, produces cloud and vapour; and from these, when still more condensed, comes flowing water, and from water comes earth and stones once more; and thus generation appears to be transmitted from one to the other in a circle. Thus, then, as the elements never appear the same, how can anyone have the assurance to maintain strongly that any of them is one thing rather than another? No one can."

3. "Water, when divided by fire or by air, on reuniting, becomes one part fire and two parts air; and a single volume of air divided becomes two of fire. Again, when a small body of fire is contained in a larger body of air or water or earth, and both are moving, and the fire struggling is overcome and decomposed, then two volumes of fire from one volume of air; and when air is overcome and cut up into small pieces, two and a half parts of air are condensed into one part of water."

Now what can we make of such passages as these? Let Plato's most famous modern commentator, Jowett, a former Master of Balliol, speak first, and enter a plea for the defence:

"Of all the writings of Plato, the *Timaeus* is the most obscure and repulsive to the modern reader, and has nevertheless had the greatest influence over the ancient and mediæval world. The obscurity arises in the infancy of physical science out of the confusion of theological, mathematical, and physiological notions, out of the desire to conceive the whole of nature without any adequate knowledge of the parts, and from a greater perception of similarities which lie on the surface than of differences which are hidden from view. To bring sense under the control of reason; to find some way through the labyrinth or chaos of appearances, either the high way of mathematics, or more devious paths suggested by the analogy of man with the world, and of the world with man; to see that all things have a cause and are tending towards an end—this is the spirit of the ancient physical philosopher. But we neither appreciate the conditions of knowledge to which he was subjected, nor have the ideas which fastened upon his imagination the same hold upon us. For he is hovering between matter and mind; he is under the dominion of abstractions; his impressions are taken almost at random, from the outside of nature; he sees the light, but not the objects which are revealed by the light; and he brings into juxtaposition things which appear to us to be wide as the poles asunder, because he finds nothing between them. He passes abruptly from persons to ideas and numbers, and from ideas and numbers to persons. He confuses subject and object, first and final causes, and is dreaming of geometrical figures lost in a flux of sense."

We have to bear in mind that Plato was before all things a mathematician (he would not admit non-mathematicians to his schools), then a dialectician. He had become conscious that there was a field of knowledge somewhere between mathematics and medicine, but it never occurred to him to place the principles of physics and chemistry first in order in philosophic disciplines—that would have been to play the traitor to his most cherished convictions.

Though knowing nothing about physical science, he

decided to write an account of it, apparently overlooking the fact that the Greek language had hardly yet become a suitable vehicle for describing physical phenomena. As we saw in the proposition that forms the substance of our first quotation from the *Timaeus*, Plato argued that since the world was to be solid, God placed between the elements of *fire* and *earth* two other elements of *air* and *water*, and he arranged them in a continuous proportion,

$$\frac{\text{fire}}{\text{air}} = \frac{\text{air}}{\text{water}} = \frac{\text{water}}{\text{earth}},$$

and in this way he constructed a heaven which was perceptible to sight and touch, the four elements being in harmonious union, indissoluble except by the hand of the framer. But what could Plato have meant? He knew really nothing about the nature of fire, air, water, or earth, and to us moderns the proportional statements are nonsensical in the extreme, but we may safely assume that Plato believed he was constructing a heaven, and a visible heaven, too, that had a real existence. For he undoubtedly believed in his four so-called fundamental elements, and we may therefore feel certain that he was supremely confident in his conclusions; he was a mathematician and he was reasoning deductively from first principles, as mathematicians always do.

Although Plato was the greatest philosopher of antiquity and a man of the very highest intelligence, he was a helpless little child when he touched anything relating to physical science. As Jowett says, "he was full of original thoughts yet liable to be imposed on by the most obvious fallacies. His *a priori* notions were out of all proportion to his experience. He was ready to explain the phenomena of the heavens by the most trivial analogies of the earth. He never tried experiments himself which would either prove or disprove his theories." He knew a great deal about astronomy and he was by no means unfamiliar with medicine, but his ignorance of chemistry was extreme. He did not know how to isolate phenomena; he had not been trained to distinguish

between the accidental and the essential; he argued from superficial analogies. From the external world he—none better—could quickly catch an inspiration, but he was incapable of generalisation and of induction in the modern sense. The chemistry and physics which form the ultimate premisses of so much of his philosophy were crude and primitive in the extreme.

And yet Plato probably did more for the ultimate advantage of physical science than his pupil Aristotle did by his collection of facts. Plato did at least insist on rigorous reasoning. Aristotle collected facts, it is true, but he took far too little trouble to check and verify them; and he hated mathematics; he probably turned his back on his master for that reason; and although he wrote a small treatise on deductive logic, the rigour of his deductive reasoning was not equal to that of Plato. And that all-important weapon of modern science, induction, was outside the range of both master and pupil. Aristotle pointed to deduction as the safe road that led to the goal and thus as a teacher of science he sinned against the light.

Instead of charging the ancient philosophers with primitive generalization, it would perhaps be fairer to say that they did not generalize at all. The checking of observations would have been a most undignified procedure. Any form of occupation with the hands lowered the standard of thought.

While it must be freely admitted that ancient physical science, especially chemistry, is full of absurdities and of nonsensical *a priori* assumptions, and seems to show an utter disregard of facts, the errors are hardly separable from the intellectual conditions of the times. After all, many of the ancient philosophers were first-rate mathematicians. They did divine that mathematical laws pervaded the world; the facts of number were familiar to them, their geometry was unexceptionable, and they made great advances in astronomy. In spite of all its many and great imperfections, the *Timaeus* remains by far the greatest effort of antiquity to conceive the world as a whole.

Both Plato and Aristotle held to the belief that the four " elements " (air, fire, water, earth) were capable of mutual transmutation, and it was a natural extension of this idea that led to the assumption and then to the belief that transmutation must also apply to the metals.

To this subject of transmutation of the metals we may now return.

2. Alchemists as Research Workers

It will now have been gathered from the last chapter that knavery was not the whole of alchemy by a very long way. Not a few of the alchemists, from the thirteenth century onwards, were serious research workers, spending laborious days and nights in their laboratories, amongst their stills and alembics, mortars and pestles, retorts and condensers, furnaces and bellows, crucibles and tongs, acids and alkalies, metals and salts, and such other chemicals as were then procurable, wearily watching, waiting and hoping. The all-important thing for checking important deductions from his experimental results—the fine balance of later days—was, alas, wanting.* Pictures of mediæval laboratories are common enough, with their blackened and smoke-begrimed beams, and all sorts of mysterious objects peeping out from the various dark corners of the almost windowless room. Lumber tends to accumulate in workshops of all kinds—" it may be useful some day "—and the miscellaneous objects of mediæval laboratories are thus easily accounted for, though the skulls, snakes, lizards and toads, owls, and the like, which so often appear in the pictures, are probably usually due to the painter's imagination, helped out perhaps by what he has seen in a modern fortune-teller's darkened sanctum.

It is worth while to refer briefly to the beginnings of chemistry in ancient times, so far as we know them.

* Rough assaying balances seem to have been in use.

3. Chemistry in Ancient Times

Early in the nineteenth century, a Swedish diplomat discovered at Thebes an Egyptian papyrus written in the third century. He sold it to Holland, and it is now in the Museum of the University of Leyden. It embodied much of the accumulated knowledge of many previous centuries, taking the form, however, not of a continuous narrative, but of a long series of recipes—recipes for metal-working, alloy-making, dyeing, the making of pigments, the making of drugs and antiseptics, glass-making, the making of imitation precious stones, and so forth. It was a sort of trade manual, written by practical men, and it added much to our former knowledge. Vinegar, nitre, and fullers' soap are mentioned in the Bible, and alcoholic beverages were certainly known in Noachian times. Whether the practical arts originated in China, India, or Egypt we do not know, but certain it is that the knowledge possessed by the Greeks and Romans was inherited from the Egyptians. The chemical art was regarded by the Egyptian priesthood as holy (*ἁγία τέχνη*); they guarded it jealously as a treasure at once precious and profitable. But such ancient Greek philosophers as Pythagoras, Democritus, and Plato succeeded in gaining the confidence of the Egyptian priests, and their writings contributed in no small measure to the spread of Egyptian knowledge.

This knowledge included a great deal about metallurgy, including the recovery of some of the common metals from their ores. Gold and silver ornaments have been discovered that date back to Neolithic times in Egypt, copper dates back to at least 3000 B.C., iron to 2500 B.C., tin to 2000 B.C., and lead to nearly the same time. These six metals are mentioned in the Old Testament. Mercury is mentioned by Aristotle's pupil Theophrastus, 300 B.C., who described its preparation from cinnabar and called it liquid silver. For many centuries the belief was tenaciously held that there was some funda-

mental connexion between these seven metals and the seven heavenly bodies, Sun, Moon, Venus, Mars, Jupiter, Saturn, and Mercury, respectively, the number "seven" having been held sacred for ages. As for alloys, bronze was actually made in 2500 B.C. Steel was known in 1600 B.C. The belief in the mysterious connexion between the metals and the heavenly bodies seems to have been the origin of the further curious belief that metals originated from seeds and pursued a steady growth in the earth, being continually vitalized by the air which penetrated from outside. Even down to the sixteenth century A.D. mines were occasionally closed for a while, in order that the metal might grow more vigorously and the mine yield a greater supply.

4. Philosopher-Alchemists and Laboratory-Alchemists

As we have pointed out in a previous section, alchemy claimed the attention, in mediæval times, of two quite different types of serious workers: (1) men who thought, speculated, theorized, and wrote, often men of great ability but who despised any sort of practical work and who therefore never had any first-hand knowledge of science, men who never dreamt of questioning the authority of Aristotle; (2) men who spent their time in *doing* things, in accumulating facts first-hand, often men of a second order of intelligence who took little interest in speculation and theorizing. Between these two classes, as might be expected, there was a recognized social distinction, the same sort of distinction that has survived almost to the present day, the distinction of broadcloth and fustian. It is not so many years ago when a university professor of philosophy was looked upon as an altogether intellectually and socially superior being to a professor of chemistry, when the classical Sixth of a Public School made scornful remarks about boys taking science. The mediæval world looked upon the philosopher-alchemist as a man who

had been inspired: what wonderful things he said! how subtle his arguments! how perfect his language! He, guilty of fallacies! Was his reasoning not perfect? And had not Aristotle himself provided him with his premisses? As for the laboratory-alchemist, who was *he*? Certainly not a man you could ask to dinner, and therefore certainly a man to be ignored.

But broad-cloth or fustian, both types of alchemists were alike in this aspect: they sought the truth, though by education and training they were both utterly unfit to pursue the search with any prospect of discovering it. The one type failed because they sought the truth by deduction; the other type failed because they were unfamiliar with induction. Many of them were genuinely self-deceived visionaries, and few of them were able to recognize the truth when they saw it. They had never been taught to analyse and criticise the difference between the false and the true, and thus they had never learnt to reject the half-truth, the casual, and the superficial. Within this narrow mental horizon they were, indeed, scrupulously honest, and it is certainly unjust to look upon them as charlatans.

The root cause of the painfully slow progress made by science during so many centuries was the complete separation of the two classes of workers. The philosopher-alchemists spun theories about a subject of which they had no first-hand knowledge; their arguments were based on rumours, gossip, and exaggerated accounts of laboratory operations which they had never seen performed and did not understand, and the very words they used were often ambiguous and devoid of any real significance. On the other hand, the laboratory-alchemists engaged in operations which were for the most part disconnected, and had a greater bearing on arts and crafts than on science; the workers were usually content if they could earn a living, though many of them were undoubtedly animated with the hope of some day making a discovery that would lead to fortune.

5. Early Ideas of Transmutation

The first vague ideas of possible transmutation not improbably arose in very remote times when by chance an apparently new metal resulted from the mixing of two other metals; that at least the softer metals would melt must have been discovered almost as soon as the metals themselves were discovered. Be that as it may, the key-note of serious alchemy, at least from the fourth to the sixteenth century, was undoubtedly the idea of possible transmutation. An eleventh-century definition of chemistry, by Suidas, was "the art of making silver and gold". In the thirteenth century, transmutation was certainly the cardinal point to which all chemical research was directed. Not a few serious workers were convinced of the reality of the philosophers' stone, and transmutation was considered to be an incontrovertible possibility. But alchemists' dogmas were, at bottom, all really Aristotelian in origin and were maintained solely on the ground of their hoary antiquity and the still undisputed authority of Aristotle. And their beliefs were strengthened by not a few of their apparently successful experiments in the laboratory. Let us, for a few moments, forget our knowledge of modern chemistry, and go back into the laboratory of an intelligent alchemist and watch him at work:

1. He heats some ordinary tap-water in an open vessel. The water boils and changes into an aeriform body (steam), leaving at the bottom of the vessel a white powder. The alchemist concludes that the water changes into *air* and *earth*.—This conclusion, made by a man wholly ignorant of the substances which the water held in solution is perfectly logical. How can we say it is not?

2. A piece of lead is strongly heated in contact with air. Immediately it loses its primitive properties and is changed into a species of ash. The ash, which is apparently the product

of the death of the metal, is put into a crucible and heated with some grains of wheat, and the metal is seen rising from its ashes and resuming its original form and properties. The alchemist concludes that metals are destroyed by fire and restored to life by wheat-grains and heat.—The conclusion, made by a man wholly ignorant of reduction and oxidation, is perfectly logical. Can we wonder that the philosopher-alchemist in his easy chair henceforth makes grains of wheat the symbol of bodily resurrection and eternal life?

3. Argentiferous lead is burned in cupels composed of ashes or pulverized bones. The lead disappears, and at the end of the experiment there is seen in the cupel a shining nugget which the alchemist concludes must be pure silver, a conclusion which, considering the alchemist's very limited knowledge, is perfectly logical. Can we wonder that again our easy-chair philosopher-alchemist, on the strength of these and analogous facts, spins out a theory of the transmutation of metals and suggests a search for the philosophers' stone?

4. A strong acid is allowed to act on copper. The copper is transformed into a transparent green liquid. Into this liquid is dipped a thin blade of bright iron. The copper appears again as a metal, and the iron disappears. The alchemist concludes that the iron has been transmuted into copper. How can we say that his logic is faulty?

That the alchemist should mistake such appearances for realities is no reflection on his reasoning and honesty. The appearances *justify* his assumption that there has been transmutation.

Admittedly it was perfectly natural for an alchemist to assume that iron had been transmuted into copper when he saw a deposit of copper on the iron utensils left in the water of the copper mines; or to assume that copper had been transformed into gold or silver when yellow and white alloys had been formed by means of such earthy substances as calamine or arsenic; or to assume that the gleaming residue which remained behind when an alloy with lead or an amalgam with mercury was strongly heated were respectively

gold and silver. It is all very well now for us to play the part of critics, to say that the alchemist's claims were, at the very best, based partly on superficial observations, partly on untenable theories concerning the composition of bodies; but had we been in their places, and had our knowledge of basic facts been as limited as theirs, should we not have drawn exactly the same conclusions as they did?

When the practical alchemist seriously settled down to solve the general problem of transmutation, there was nothing inherently absurd in the problem. *It is the essential nature of chemical change that a given substance with certain properties disappears while another with different properties takes its place.* There was nothing in the knowledge of those centuries from which there was any justification for concluding that it was any more impossible to obtain gold from lead than to obtain lead from litharge or mercury from cinnabar.

The theorizing of the philosopher-alchemists, though for the most part so nonsensical to us moderns, is interesting if only because it serves to show how rationally-minded and able men may so easily go astray when they have no first-hand acquaintance with the facts they theorize about. Though the philosopher-alchemists made great use of Aristotle's theory of 2000 years before, they went further and worked out a much more complete theoretical system, though much of it is as vague, as incomprehensible, and as absurd as Aristotle's own. We give a short outline of its foundations.

The mediæval alchemists recognized:

1. *The Unity of Matter.*—They held that matter is *one* but can take a variety of forms from which an infinite variety of combinations can be effected. Although this *prima materia* changes its form, it cannot be destroyed.

2. *The Three Principles.*—All metals and minerals consist of the three "Principles", philosophers' mercury, philosophers' sulphur, and philosophers' salt.

3. *The four Elements.*—These were the four Aristotelian "elements", fire, earth, air, and water.

4. *The seven Metals*, gold, silver, mercury, copper, iron,

tin, lead, corresponding, respectively, to the sun, moon, and five planets. In Chaucer's *Canterbury Tales*, the Canon's Yeoman refers to the seven metals thus:

> " Sol gold is, and Luna silver we threpe,
> Mars iren, Mercurie quyk-silver we clepe,
> Saturnus leed, and Juppiter is tyn,
> An Venus copper, by my fader kyn."

Of these metals the mediæval alchemists regarded gold and silver as *perfect* because they were unalterable by any matter with which the alchemists were acquainted. The others were *imperfect* because each could be transformed into a calx or oxide and was attacked by acids. They thought it possible to purify the imperfect metals by administering " medicines " to them, and so transmuting them into perfect.

On such foundations the philosopher-alchemists built up a considerable body of doctrine, call it philosophy, theory, or what you will. It was all wildly speculative, having only the slenderest connexion with experimental facts. The one really happy shot concerned the unity of matter. The laboratory-alchemists, led away by the philosopher-alchemists, became ineradicably obsessed with the idea of the transmutation of metals, and it was this obsession which gave a special bias to the greater part of their practical work in the laboratory.

6. The Birth of Modern Chemistry

The philosopher-alchemists had their first really bad shaking-up at the hands of a Swiss physician who, at the age of 33, became professor of medicine at the University of Basle. This was **Paracelsus** (more correctly, Philippus Aureolus Theophrastus Bombastus von Hohenheim), a man to whom most historians have shown such a violent dislike that they have called him an " impudent adventurer ", a " madman ", a " charlatan ", and they have gravely coupled

his name with that of Cagliostro, "the two greatest charlatans of history". But such an estimate of Paracelsus is altogether beside the mark. Aggressive, vitriolic-tongued, vain, intemperate, and hated by almost everybody, he certainly was; but he was not a rogue. At his very first lecture he ostentatiously burned the works of Galen and Avicenna, the great medical authorities of that age. He gave an entirely new outlook to chemistry by insisting that its main business was the preparation of *drugs* and other remedies for use in medicine. "Away with those false disciples who hold that the divine science, which they dishonour and prostitute, has no other end but the making of gold and silver. True alchemy has but one aim and object, to extract the quintessence of things, and to prepare arcana, tinctures, and elixirs, which may restore to man the health and soundness he has lost." He advocated the use of antimony, and is said to have been the first to use laudanum. He scorned the philosopher-alchemist's favourite working instrument, the syllogism. Naturally he met with the most vehement opposition, both from the philosopher-alchemists and from the very conservative medical schools of those times.

His onslaught on existing orthodoxy was so irresistible that he swept away many features of the older type of alchemy. His views were often ridiculous, sometimes superstitious, always dogmatic, but rarely traditional. It is true that the search for the philosophers' stone and the elixir of life went on for another two centuries, but that search was no longer the main end of chemistry. Chemistry was at last a subject worth studying for its own sake. The great debt which chemistry owes to Paracelsus is his entirely new outlook on the practical side of his subject. The kind of work he introduced was bound to undermine the whole doctrine of the philosopher-alchemists, though apparently Paracelsus adhered in some measure to certain aspects of that doctrine all his life, for he never quite gave up some of its more mystical phases. It is perhaps impossible for any reformer absolutely

to force his mind from all the preconceptions of a discarded belief. A cardinal principle of Paracelsus was that neither chemistry nor medicine could ever become static; each must be allowed to grow and develop, in the light of newly discovered facts. To him a closed and final system was anathema. He left us a fine motto: " Let him not belong to another who may be his own ".

A contemporary of Paracelsus was **Georg Agricola** (1490–1555) who, however, was anything but a fiery controversialist, and the accurate and clear records of his researches constituted a valuable handbook until quite recent times.

Robert Fludd (1574–1637), a Kentish physician, though he lived a little later, is generally looked upon as an ardently devoted follower of Paracelsus. He was a member of that mystical Order, the Rosicrucians, an Order scattered all over Europe without headquarters or known leaders. Fludd wrote at great length, mostly in obscure Latin, but it is doubtful if he materially advanced the cause he had so much at heart.

Jan Baptista van Helmont (1577–1644) was a Belgian physician and a follower of Paracelsus, though he could not bring himself to surrender his belief in some of the far-fetched alchemical theories. He actually describes in great detail the transmutation of mercury into gold and silver, with the aid of a very small quantity of the philosophers' stone. But, even if so absurdly credulous, he was an untiring and highly competent original investigator. His outstanding discoveries were in connexion with gases. It was he who invented the term " gas ". Those strange bodies which escaped from the retorts of the early alchemists had first been called by them " souls "; later, when known more intimately, they were called " spirits "; and now they were called " gases ". Unfortunately Helmont could not devise means for collecting gases, or chemistry would probably have leaped ahead at once as a serious subject of science. Helmont was ignorant of the action of the oxygen of the atmosphere, and naturally

PLATE II

CHEMICAL LABORATORY—AN ALCHEMIST AT WORK

By Pieter Breughel

therefore he was unaware of the fundamental difference between experiments performed in closed vessels and in vessels open to the air.

However, Helmont is sometimes referred to as the midwife who was present at the birth of chemistry, for chemistry as a science was really born when the age-long endeavours to discover the actual composition of substances became genuinely fruitful. Alchemy soon faded away, except in so far as it was kept alive by charlatans. The seventeenth and eighteenth centuries produced a succession of brilliant investigators—Becher, Stahl, Mayow, Boyle, Black, Cavendish, Priestley, Scheele, Lavoisier, and others—and there was no going back, though "phlogiston" took a great deal of slaying. The new race of chemists combined the functions of both the philosopher-alchemist and the laboratory-alchemist. There were no longer two independent classes of workers. Henceforward progress was rapid. But even Boyle, eminent man of science as he was, could not completely rid himself of the idea of transmutation. The beliefs which we drink in with our mother's milk sometimes seem to be part of our very life-blood.

Chemistry owes an enormous debt to the laboratory-alchemists who, however deluded and credulous they may have been in some ways, did devise experiments, did search for new facts, did discover the properties of things, did discover relations between things, and did pave the way for the quantitative work which the chemists themselves undertook later. They necessarily failed to discover how to transmute the common metals into gold, but in their search they made other discoveries which has since brought the world wealth beyond their wildest dreams. It was these practical results which led to the complete overthrow of the easy-chair philosopher-alchemists, with their verbal quibbles and their hair-splitting scholastic jargon.

But has the alchemists' fundamental notion of transmutation been finally discredited even now? In the opinion of the great French chemist, **Dumas**, the theoretical possi-

bility of making gold artificially might be found in the doctrine of isomerism. And our own Sir Humphry Davy refused to say that the alchemists were necessarily wrong. And what inferences are we to draw from present-day research?

7. Modern Transmutation

The atoms of all substances are now known to belie their name (Gk. ἄτομος, indivisible): they are *not* indivisible, they are all composite bodies, all made up of the same ultimate particles, these particles simply differing in number. These ultimate particles are mainly* of two kinds, *protons* and *electrons*. The atom of one element differs from the atom of another simply in the number of protons and electrons it contains. All protons are alike and are believed to be simply positive charges of electricity; all electrons are alike and are believed to be simply negative charges of electricity. The proton is very dense and its mass is 1845 times that of the mass of the extremely light electron. According to the hypothesis now generally accepted and supported by a great deal of experimental evidence, the atom is analogous to the solar system, in that it has a heavy dense *nucleus* round which *electrons* revolve, like planets revolving round the sun. The weight of the electrons is so entirely negligible that the *atomic weight* may be thought of as simply *the weight of all the protons.* The nucleus always contains all the protons and therefore carries practically the whole mass of the atom. The nucleus is also positively charged though it consists of two distinct parts: (1) an inert core consisting of about half the protons neutralized by an appropriate number of electrons, apparently taking no part in the active properties of the atom; (2) the remainder of the protons, grafted in some way on the neutral core, *active* with their positive charges, and contributing to the electrical behaviour

* For simplicity, we ignore the *neutron* and the *positron*, though it is known that these play an important rôle. See Chapter IX.

of the atom. The number of these *active protons* is always equal to the number of the revolving *planetary electrons*. It is the planetary electrons that mainly determine the chemical behaviour of the atom. More fundamental than the atomic weights are the *atomic numbers*; these represent the number of *active protons* in the nucleus and therefore also the number of *planetary electrons*. The 92 elements may be arrayed in arithmetical progression, with atomic numbers 1 to 92.

Naturally chemists were quick to see that if they could devise means to disrupt an atom and eject some of its particles, the residual atom would be lower down the atomic scale, and they would have effected transmutation.

Sir J. J. Thomson first attacked the problem in the late nineties. He ejected from certain atoms one or more of the planetary electrons, using for the purpose very swift particles, or ultra-violet radiation, or X-rays. The modified atom was naturally left with a positive charge, and it had different properties from the original atom. But the change of properties was only momentary, for in a very short time another electron fell into the atom and the atom was restored to its original constitution. It is now considered impossible to cause a permanent transmutation of an atom by removing or adding outside electrons.

But workers all over the world are now attacking the massive *nucleus*, a very difficult thing to do because it is held together so strongly. One method of procedure is to bombard it with particles travelling at a very high speed, for instance with the α-particles spontaneously ejected from radium. In this way several of the lighter elements have been successfully transformed, all, of course, on a very minute scale. Success in the disruption of heavier atomic nuclei is now also being obtained rapidly by improved methods of bombardment, especially in regard to the particular projectiles chosen. But on the atoms of some of the elements no effect has yet been produced.

Great ingenuity has recently been shown in devising

apparatus for effecting more powerful bombardment. Dr. **E. T. S. Walton** and Dr. **J. D. Cockcroft** of the Cavendish Laboratory, Cambridge, have used bombarding protons with energies up to 700,000 volts, and have been able to disintegrate lithium, boron, and fluorine. Professor **E. O. Lawrence** of California has devised a method, depending on multiple acceleration, of obtaining bombarding particles of tremendous energy. His wonderful **Cyclotron** can accelerate helium nuclei (α-particles) until they obtain the enormous energy of 11 million volts! Why such tremendous speeds?

If we could produce very high temperatures, disintegration of atomic nuclei would be a very simple matter, inasmuch as the necessary energy would then be available; but we cannot obtain laboratory temperatures much above a paltry 3000° C. By means of the Cyclotron we can, however, produce energy-equivalents of enormously high temperatures; one million volts is the energy equivalent of 7,000,000,000° C. Very rapid progress in transmutation is now being made: boron has been transmuted into helium, aluminium into phosphorus, magnesium into sodium, and platinum into gold.

The apparatus and machinery for these experiments is elaborate and costly, especially the machines for producing high electrical potentials. (A detailed and illustrated description of the Cyclotron may be seen in Andrade's *New Chemistry*.)

We are a very long way off the transmutation of elements on any sort of practical scale. As for the artificial making of gold in bulk, that must still remain a dream of the far, far future.

Can it be that, after all, the philosophers' stone has actually been discovered? Can it be some type of electrical gun, a future form of the cyclotron?

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CHAPTER IV

Witchcraft *

1. "Evil Spirits"

It is a natural thing for primitive man to be impressed by any natural phenomena that appear to him to be in any way abnormal. Those aspects of nature which startle him are almost certain to terrify him. He cowers before the fiery tail of the comet; he shivers in the gloom of the eclipse; he is appalled at the sight of a mighty oak riven by lightning and falling to the earth with an accompanying crash of thunder; earthquakes fill him with an unconquerable dread. To him it is utterly unbelievable that any of these things are merely parts of a sequence of natural causes and effects; he is convinced that the unseen and unknown causes are *super*natural and *super*personal; his imagination creates an active agent in form something like himself though far more powerful, an agent which remains invisible and is therefore far more to be dreaded than one which could be seen. It is in this way that his imagination gives birth to "spirits", and as these always seem to be hostile and destructive, the spirits are regarded as "evil" spirits. He soon comes to believe that these evil spirits are always near him and that it would be prudent to propitiate them with gifts.

The evil spirits thus created by primitive savages are

* The substance of this chapter and of Chap II is taken from certain sections (Vol. I, Chaps. I and IV, and Vol. II, Chap. I) of the historian Lecky's *The Rise and Influence of Rationalism in Europe* Lecky's phraseology is a little prolix and has therefore been modified, but the references in the footnotes (to Longman's reprint of 1904) will enable the reader to turn to the originals. Not the least advantage of Lecky's work is his own references to the leading authorities, ancient, mediæval, and modern. I have verified many of these and never found an error.

never finally exorcised until civilization reaches an advanced stage.*

As society emerges from its primitive state, an unscrupulous impostor will from time to time arise. He may be a man of considerable ability, he is perhaps a man of unusual cunning and daring, he is probably an ambitious man lusting for personal power and gain, and he may have given careful attention to the working of nature; and he will almost certainly profess to hold communication with and to control supernatural beings. These claims enable him not only easily to acquire almost boundless influence over the multitude, who are intensely predisposed to believe in the supernatural, but also to wreak vengeance upon those who have offended him, for he will probably charge them with being the direct cause of some dire calamity and will thus convert popular terror into popular anger. Who would dare to question information derived from supernatural sources?

All down the ages, until comparatively recent times, evil-spirit mongering was a lucrative, though rather dangerous, profession. Sorcerers of different types abounded, so did practitioners of "magic".

But these men, who were always feared, were almost always hated. Believed to be in communication with evil spirits, and even to be the willing active agent of the arch evil spirit, the Devil himself, they always ran the risk of colliding with constituted authority, civil and ecclesiastical.

But the multitude often failed to discriminate between the few real impostors and a class of men (and women) whose solitary and unusual habits and often abnormal appearances made them objects of suspicion: if the peculiarities of this class showed any signs of irrationality, due perhaps to some brain trouble, the suspicion that they were in the habit of communicating with evil spirits became a certainty. The recognition of a brain disease as the prime cause of any form of mental trouble is the result of modern discovery. In old days a person who because of some brain trouble had become

* Cf. Lecky, I, p. 16 ff.

irrational was labelled "mad"; evil spirits must have brought it about, and the poor patient himself was probably adjudged guilty rather than innocent.

The belief in the existence of evil spirits became so deeply engrained in the mind of primitive man that for centuries, even millenia, the belief survived in, and became absolutely ineradicable from, the minds of his civilized descendants. It was universally taught that countless evil spirits range about the world, seeking the present unhappiness and the future ruin of mankind, and directing against everybody the energies of superhuman malice.

Witchcraft, as it was called, was the result of the belief in evil spirits, of superstition, of imposture, and of ignorance. From early mediæval times right down to the seventeenth and eighteenth centuries, witchcraft occupies a prominent place in the history of western civilization.

During that long period the "measure of men's probability" was essentially theological. Men always tended to accept as true, on the very slightest evidence, often mere hearsay evidence, whatever tended to square with their feelings and their wishes, and their measure of probability ultimately determined the details of their creed. This tendency survives even now, but in those days the predisposition to believe in the miraculous was so great that out of a very small number of recognized facts of nature, a vast and complicated system of witchcraft was constructed, round which there accumulated an immense mass of wildly impossible circumstantial "evidence". For many centuries all men believed that witchcraft was incontestably true; and although subjected to the scrutiny of the law courts of every European nation, it survived unshaken, and tens of thousands of victims were consigned to a fearful and unlamented death. The reason why there was not the smallest desire to explain away or soften down miraculous accounts, in order to make them harmonize with experience, was because the minds of men were completely imbued with an order of ideas that had no connexion with experience. In those days the theologians reasoned as if they

could actually *see* evil spirits, beings absolutely untrammelled by the laws of nature and hovering around and watching every human action with a deadly malignity; as if they could actually *see* the angel of destruction brandishing the sword of death over the Assyrian hosts; *see* Satan transporting Christ through the air; *see* the demoniacs foaming in agony beneath his grasp. With their minds so pervaded by those awful images, men formed a measure of probability entirely different from that which is now formed by the wider and unified experience of modern life. Mankind seemed to have the inexpugnable feeling that evil spirits were always present, and there was a universal disposition to discover manifestations of their powers.

The belief that evil spirits could wreak their vengeance upon mankind was general even in the earliest days of ancient Greece and Rome, and St. Augustine assures us that the Epicureans were the only philosophers who denied the existence of evil spirits. There was a law condemning magicians to death, and in the days of Demosthenes a sorceress named Lamia was actually executed. In those ancient civilizations, however, the persecution was virtually free from religious fanaticism. The magician was punished because he injured man and not because he offended God, and the prosecution was never more than lukewarm.

The early Christians scattered about the Roman empire were inspired by an intense religious enthusiasm, but their belief filled them with a sense of Satanic presence: their own tiny world formed the Kingdom of God, and the great persecuting world the Kingdom of Satan. In the great and ancient religion which they found subsisting around them, with its gorgeous rites, its traditions, its priests, and its miracles, they saw the hand of the Devil. They adopted the conception of subsidiary spirits, but they maintained that these were all the adversaries of the Deity, not His willing agents. This notion was elaborated by Tertullian * (*c.* 160–

* See *De Cultu Foeminarum*, lib. i, c. ii.; and St. Augustine, *De Civ. Dei*, lib. XV, XXIII. See also Lecky ,I, p. 22 *seq.*

230 A.D.) who tells us that the world was full of evil spirits whose influence might be descried in every portion of the Pagan creed. Some of them belonged to the band of rebel angels who, headed by Satan, had been cast out of heaven; others were angels who in the "antediluvian" world had become attached to the daughters of men: others were the more immoral deities of heathenism, like Venus, Mars, Mercury, Pluto: others though morally less reprehensible were nevertheless undoubtedly diabolical: Minerva the wise was a devil, so was Diana the chaste, so was Jupiter the heathen's Most High. Marriage with devils was one of the commonest accusations in witch trials.

We have it on the authority of the Bible that more than 1000 years before the Christian era, Saul, the first king of Israel, "put away those that had familiar spirits and the wizards out of the land". Nevertheless he became so alarmed at the invasion of the Philistines that he disguised himself and went by night to Endor to consult the local witch.* Officially he had suppressed witches but in his heart he still believed in them.

2. Witches at Home and in Conference

One of the most striking characteristics about old Catholic theology was the extraordinary dislike, even the passionate horror, of women. Celibacy was universally regarded as the highest form of virtue, and in order to make it acceptable theologians exhausted all the resources of their fiery eloquence in describing women's innate wickedness, unparalleled malignity, inconceivable subtlety, and unconquerable frivolity, unfaithfulness, and evil propensities. The reading of such diatribes nowadays is likely to be provocative of mirth, but it is a melancholy fact that the teaching they represent had great influence in predisposing men not only to believe in witches but to contemplate with extreme callousness the

* 1 Samuel, xxviii.

sufferings which the victims were often forced to undergo. The question why the immense majority of those who were accused of sorcery should be women early attracted attention, and the invariable answer was that it was because of the inherent weakness of the sex. Both **Cato** and **Cicero** expounded themselves in such terms. **Solomon** had summed up his own extensive experience in a long series of most crushing apophthegms. **Chrysostom** interpreted the general sentiment of the Fathers when he pronounced women to be " a necessary evil, a natural temptation, a domestic peril, and a deadly fascination ". A woman who by her fascination " bewitched " a man was necessarily a " witch " and was therefore possessed by an evil spirit. So ran the argument.

What was a witch like in real life? * Occasionally a woman reputed to be a witch was an undoubted adventuress. Greatly daring, she would flout the law and proclaim herself a sorceress who possessed authority derived from the Devil. Utterly unscrupulous and vindictive, she often lived in a remote hut amidst surroundings well calculated to scare away all visitors, but she usually made a good living from the presents she received from people in whom she contrived to inspire a dread of dire happenings which would befall them if her price was not paid. Sometimes such a person was laid by the heels and well merited the punishment meted out to her. Usually, however, the women reported to be witches were elderly, and of an absolutely harmless character, women who perhaps had never recovered from some family bereavement, perhaps were badly disfigured or deformed and preferred to hide themselves away from their fellow-beings, perhaps had been shunned because of their unusually unpleasant habits, perhaps were markedly neurotic or hysterical and suspected of being " mad ". At the worst they were just poor, degraded old women leading solitary lives. **Scott** described them thus: " They are women which commonly be old, lame, bleare-eyed, pale, and full of wrinkles. . . . They are lean and deformed, showing melancholic in their faces ". And

* Lecky, I, p. 46 *seq.*

Harsnet describes a witch as "an old weather-beaten crone, having her chin and knees meeting for age, walking like a bow, leaning on a staff, hollow-eyed, untoothed, furrowed, having her lips trembling with palsy, going mumbling in the streets." The two writers referred to saw nothing in these so-called witches but poor, despised, and perhaps degraded old women. The present writer remembers, as a boy, one such old woman. She had lost her husband and all her eleven children. She lived in a remote cottage, kept a few domestic animals, and grew a variety of herbs which she sold in a town a few miles distant. Once a week she visited the little general shop in the local village and made a few very small purchases, but everybody shrank from her and spoke of her as an "old witch" whose very look might blast them. Actually she was a harmless, broken-hearted old woman who desired nothing better than to be left alone.

Joan of Arc (Jeanne d'Arc) who was only a girl of twenty when in 1431 she was burnt at the stake in Rouen, is sometimes described as a witch, sometimes as a sorceress. She claimed to have received supernatural guidance, not however from hell but from heaven. These days she would probably have been adjudged to be mentally unstable. Be that as it may, the nobility and unselfishness of her purpose was never questioned, and all the efforts of her judges failed to bring to light the smallest semblance of conscious dishonesty on her part, and there is no doubt whatever that in the end she was a victim to the cruelties of a superstitious age. The rôles then played by the French, the Burgundians, the English, and even the Church itself, were all thoroughly discreditable.

When we come to the outrageous things that were *said* about the old women supposed to be witches, and not only said but for centuries actually believed by highly responsible people as well as by the multitude, it is puzzling to understand how such gross superstitions could have become so universal. A witch was conceived to be one who had entered into a deliberate compact with Satan, and had thereby become endowed with the power of working miracles whenever she

pleased. **Spalding** has shown, by extracts from old indictments against women accused of witchcraft, that witches were reputed to possess the powers of foretelling future events, of vanishing from the sight, of bewitching cattle, of creating storms, of causing leaks in ships, of blasting corn, of sailing in sieves, of opening locks. Witches regularly attended their Sabbath to do homage to the Devil, to which they were transported in a few minutes (the distance was immaterial), either on a broomstick or on a goat. All these things now seem grotesquely absurd, but it would not be just to ascribe them to any sort of mental aberration on the part of people who hold such beliefs. That the so-called witches were really possessed by evil spirits was generally believed with an honesty that admitted of no question whatever. The travelling of witches on a broomstick through the air, for instance, was always accepted as an indisputable fact simply because the narrative conformed exactly with the theological conception of a spirit. Had not Satan borne Christ through the air and placed him on the pinnacle of the temple? and therefore, said St. Thomas Aquinas, if Satan could do this to one body he could assuredly do it to all. Thomas Aquinas! Thomas Aquinas and his famous master, Albertus Magnus, were by far the ablest of the scholastic theologians, and when in those days such men took the lead, most others were almost certain to follow.*

3. Witch Persecution

For more than 1500 years it was universally believed that the reality of the crime of witchcraft had been clearly established by the Bible, and that the amount of evidence testifying to its prevalence was so ample and so varied as to preclude any possibility of doubt. The clergy denounced it with all the emphasis of authority. The legislators of almost every land enacted laws for its punishment. Acute judges whose

* Cf. Lecky, I, p. 72 *seq.*

lives were spent in sifting evidence, investigated the question on countless occasions and were convinced that the crime was a common one. Tens of thousands of victims, most of them extremely ignorant and extremely poor, were condemned to die by the most agonizing and protracted tortures, without exciting the faintest compassion. Nations which were completely separated by geographical position, by interest, and by character were on this one question united. In Germany, France, Spain, Britain, Switzerland, and Sweden, the persecution raged with a fearful intensity. Seven thousand victims were burned at Trèves alone; at Toulouse, the seat of the Inquisition, four hundred perished at a single execution. **Remy,** a French judge, boasted that he had put to death eight hundred witches in sixteen years. **Torquemada** (1420–98) devoted himself to the extirpation of witchcraft as zealously as to the extirpation of heresy. And so it was generally throughout western Europe. The cruelties almost universally practised century after century were revolting in the extreme.

The Church of Rome proclaimed aloud the reality and the continued existence of the crime. She taught that to spare a witch was a direct insult to the Almighty. Successive Papal Bulls gave a fearful impetus to the persecution. In a word, the continued existence of witchcraft formed an integral part of the teaching of the Church, and the persecution which raged through Europe " was supported by the whole weight of her infallibility ".*

Witch trials now seem to us to have been for the most part ghastly farces. An old and half doting woman, perfectly innocent and pleading her innocence pathetically, would soon falter before the majesty of the law, and would eventually be driven to ask timidly whether it was possible to be in communication with the Devil without being conscious of the fact; finally, she would almost persuade herself that she had done what was alleged against her. Very often

* See Madden's *History of Phant.*, Vol I, pp. 234–48, and Theirs' *Superst.*, tom. I, pp. 138–63.

the terror of the trial, the prospect of the most agonizing of deaths, and the frightful tortures that were commonly applied, quite overpowered the old woman's understanding; her brain reeled beneath the accumulated suffering, the consciousness of innocence disappeared, and the wretched victim went raving to the flames, convinced that she was about to sink for ever into perdition. The tortures were often made all the more horrible because it was generally believed that the witches had charms to deaden their effect.*

Actually, the witch trials were usually conducted with all seriousness and with a strict desire to do justice. But the presiding judges, lay or ecclesiastical, were obsessed with the conviction that there was no fact in all history more fully attested than witchcraft, and that to reject it would be to strike at the root of all historical evidence of the miraculous. The tribunals often included the acutest lawyers and ecclesiastics of the age. The judges had no sort of motive for desiring the condemnation of the accused, and, as conviction would be followed by a fearful death they had the strongest motives for exercising their power with caution and deliberation. About some of the details of witchcraft there was some controversy it is true, but about the main *fact* of witchcraft there was, for centuries, practically universal certainty. Let the accused show an abnormality, however slight, whether physical or mental, in habits or in mode of life, that was presumptive evidence of guilt, viz. the guilt of being possessed by an evil spirit. More likely than not the chief witness would have a merely imaginary grievance against the accused: perhaps an apple tree had withered, the only possible cause was blighting by a witch, and the only witch in the locality was the accused. How could a tortured, ignorant old woman stand up to the series of leading questions fired at her by a clever hostile lawyer? Almost scared out of her wits, she was bound to break down and to be condemned. It would never occur to anybody that she was condemned unjustly. The condemnation seemed to be in accordance with the

* See Scott's *Discovery of Witchcraft* (London, 1665); cf.Lecky, I, p. 63 *seq.*

evidence attested, a fact which is easily understood if we remember that in the minds of judges, lawyers, and witnesses alike, there was an ineradicable obsession that witchcraft was a fact and not a fantasy. How the evil spirit " possessed " the witch, nobody pretended to know. It might be that he had curled himself up in the form of a directing little imp in the pineal gland of the brain, it might be that he was an ethereal high-voltaged (as we might say nowadays) wraith co-extensive and co-terminous with the witch's body. Who could tell? Whether the judges expected the possessing devil to be tortured and burnt when they tortured and burnt the body of the witch herself, history does not record. The judges were not intentionally unjust men or intentionally cruel men. They were the intellectual victims of the superstitions of the age in which they lived. The long train of circumstances which culminated in the Reformation had diffused through Christendom a religious terror, and even the most intelligent men were imbued with an intense and vivid sense of the Satanic presence. It seemed therefore a paramount duty to prosecute the witches, and the delusion that witchcraft was real, far from being dispelled, became more and more deeply rooted in the minds of all ranks of society.

4. Prominent Believers in Witchcraft

A famous Chancellor of the University of Paris was **Jean Gerson** (1363–1429), recognized as probably the master intellect of his age. He fought hard against the evils of the Church, but he wrote in vigorous terms a defence of the belief in witchcraft. Another Frenchman, **Jean Bodin** (1530–96), a man of great learning and probably as great a political philosopher as Machiavelli himself, "so liberal-minded as to be thought an atheist", also devoted himself to defending the belief in witchcraft.*

Between the Reformers and their opponents, there was

* Cf. Lecky, I, pp. 66 ff.

no sort of conflict on the question of witchcraft. Both parties were in complete agreement.

The credulity which the reformer **Martin Luther** (1483–1546) manifested on all matters connected with diabolical intervention was amazing, and when speaking of witchcraft his language was emphatic and uncompromising. "I would have no compassion on these witches," he said, "I would burn them all." * But the most clearly marked feature in the character of Luther was his intense and passionate sense of sin, and Satan became the dominating conception of his life. To understand Luther aright we must remember that fear was the most compelling force in his life. He had entered the priesthood as the result of a fright caused by a flash of lightning. The intensity of his devotion has never been doubted, and to those who did not question his beliefs he showed unfailing kindness. His purity of motive and compelling personality would have ensured him of a following in any circumstances. But it is essential to remember that in every critical event, in every mental perturbation, he recognized Satanic power. For centuries a black stain in the castle of Wartburg marked the place where he flung an ink-bottle at the Devil. All his life he seemed to be convinced that he was fighting against Satanic suggestions, and witchcraft never presented to his mind the slightest improbability.

Archbishop Cranmer directed his clergy to seek for "any that use charms, sorcery, enchantment, witchcraft, soothsaying, or any like craft invented by the Devil." **Bishop Jewel,** preaching before Queen Elizabeth, said, "witches and sorcerers are marvellously increased within your Grace's realm. Your Grace's subjects pine away even unto the death; their flesh rotteth, their senses are bereft;" and he expressed the hope that penalties might be rigorously enforced.

King James I did not hesitate to ascribe his stormy passage from Denmark † to the machinations of witches, and after his accession to the throne of England he caused

* *Colloquia de fascinationibus.* See also Baxter's *World of Spirits*, pp. 126–7.
† Cf Lecky, I, p. 104.

to be enacted a law which subjected witches to death on the first conviction; Coke was then Attorney-General and Bacon a member of Parliament, and twelve bishops sat on the Commission to which the matter was referred. "The High and Mighty Prince James" took every opportunity to revile those who did not share his pet superstitions, and the prosecutions that followed, especially in Lancashire, form an indelible stain on his memory. His son Charles I was much more tolerant over this particular matter, but during the Commonwealth and the Puritan ascendancy, the pursuit of witches won a new and fearful impetus. Even **Sir Thomas Browne** (1605–82) declared that those who denied the existence of witchcraft were not only infidels but also by implication atheists.*

During the few years of the Commonwealth, more alleged witches perished in England than in the whole period before and after. It was simply the natural result of Puritanical teaching, which predisposed men to see Satanic influence in life and consequently to visualize vividly the phenomena of witchcraft. A panic on the subject spread throughout the country, and the county of Suffolk became especially agitated, a certain **Matthew Hopkins**, the son of a Puritan parson in that county, having pronounced the locality to be infested with witches.† A commission of inquiry was appointed and two distinguished Presbyterian divines were selected by Parliament to accompany it. This action of Parliament was exactly calculated to stimulate both prosecution and persecution. One result was that Hopkins set himself up as a witch-finder, and East Anglican towns vied with each other to obtain his services. Hundreds of harmless old women, and not a few old men, were hunted out, and a large number were executed. The most pathetic case was that of an eighty-year-old Anglican clergyman, **John Lowes**, a man of irreproachable character, who for over fifty years had been minister of his church. Somehow he fell under Hopkins's suspicion. He was kept awake for several successive nights,

* *Religio Medici*, p. 24 (ed. 1672). † Cf. Lecky, I, p. 107.

he was tied up and thrown into a pond to see if he would sink or swim, and eventually he was hanged. During the trial the old man's brain gave way, and his torturers extracted from him a wild romance which was afterwards reproduced by **Baxter** "for the conversion of the Sadducee and the infidel." * And Baxter has been called "the greatest of the Puritans"! Baxter's venom was incomprehensible: he told the story of Lowes in these words: "Among the rest, an *old reading parson* named Lowes, not far from Framingham, was one that was hanged, who confessed that he had two imps and that one was always putting him on doing mischief and (being near the sea) as he saw a ship under sail, it moved him to sink the ship, and he consented and saw the ship sink before him." † Be it remembered that Lowes and Baxter were brother parsons! However, Baxter was himself to learn later on what a bully's brutality meant, as may be seen in Macaulay's account of Baxter's trial before the infamous Judge Jefferies.‡ At one of the Suffolk trials aforementioned, no less a man than **Sir Thomas Browne**, the great physician, was called as a witness, and he swore "that he was clearly of opinion that the persons were bewitched." It is a remarkable fact that Hopkins the witch-finder seems to have been genuinely convinced he was doing a noble work.

The Pilgrim Fathers carried to America the seeds of the superstition, which soon flourished with fearful vigour in Massachusetts. Two Puritan Ministers, **Cotton-Mather** and **Parris**,§ took the lead. A judge named **Stoughton** became their willing tool, and a panic soon became general throughout the colony. Scourgings and tortures added to the terrorism of the pulpit, and executions were common. One old man of eighty was actually pressed to death. Cotton-Mather wrote a history of the trials, and an edition was specially prepared for the English public by Baxter who commented in extremely eulogistic terms on Cotton-Mather's crusade.

* *ibid.*, p. 108. † *World of Spirits* p. 53.
‡ Macaulay's *History of England*, Chap. V. § See Lecky, I, p. 120.

In reviewing the history of witchcraft in England, it is impossible to avoid observing the favourable contrast which the Anglican Church presents both to Continental Catholicism and to Puritanism. The general moderation of most of the higher Anglican clergy was beyond praise; even those who were most credulous were singularly free from that thirst for blood which was elsewhere so common. On the Continent it was commonly urged that the crime of witchcraft was treason against God, and that therefore to punish it by any other but the most agonizing deaths was but an act of disrespect to Him. But terrorism took its most extreme form in Puritan Scotland, where clerical tyranny was maintained with inexorable barbarity. Credulity was universal. The intellect was numbed. By means of utterly unscrupulous inquisitions, confessions were wrung from suspected women, often feeble and half-doting, and the most barbarous tortures were applied to them.*

The details of these later Puritan trials are too horrible to quote, but we may refer to the earlier trial of one Dr. Fian who was suspected of having caused the storm which made King James's passage from Denmark so unpleasant. Confession was wrung from Fian by torture, which, however, he retracted immediately. Every form of torture was then in vain employed to conquer his obstinacy. The bones of his legs were broken into small pieces in the boot and all the torments that Scottish law knew were successively applied. At last the King, who personally presided over the tortures, suggested a new device: Fian's "nailes upon all his fingers were riven and pulled off by an instrument called a turkas, and under everie nayle there was thrust in two needels over, even up to the heads". However, "so deeply had the devil entered into his heart that he utterly denied all, and he was burnt unconfessed." † Happy indeed would have been later Scottish sufferers, could they have got off so lightly as Fian.

* See Pitcairn's *Criminal Trials of Scotland*, and Dalyell's *Darker Superstitions of Scotland*.

† Pitcairn, *op cit*, Vol I, part ii, pp. 203, 223. See also Lecky, I, p. 129 *seq*.

As a torturer King James no doubt did his best, but ingenious as many of his horrible devices were, he was a mere bungling amateur compared with some of his Scottish subjects.

5. The Decline of Witchcraft

Samuel Butler (1612–80) published his *Hudibras* in the early years of the Restoration. It was a satire on the Puritans and nobody more enjoyed the pungency of its wit and the resistless power of its railleries than the new King, Charles II. The reference it makes to the action of Parliament in appointing Puritan divines on the Suffolk witch inquiry is worth quoting:

> " Hath not this present Parliament
> A ledger to the devil sent
> Fully empowered to treat about
> Finding revolted witches out?
> And has not he within a year
> Hanged three score of them in one shire?" &c.

This was a sign of the times. On the subject of witches a very pronounced scepticism was beginning to show itself. Men recoiled more and more from the narratives concerning witches and came to look upon them as palpably and grossly improbable. The belief in witchcraft had been due less to scientific ignorance than to a general predisposition to see Satanic agency in life. It had reflected the prevailing modes of religious thought. Even in the Middle Ages, however, there had been a few men who had in some degree dissented from the common superstitions, though by the multitude their opinions were deemed entirely incomprehensible. Men were far more inclined to accept wild gossip concerning witches than to reject it. To suspect and scrutinize such " evidence " was in itself almost sinful, and anyone who dared to do it was looked upon with grave suspicion. During the Middle Ages, and even during Reformation times, there was an extraordinary reverence for authority, and not until

this was overpowered by the irresistible force of the extreme improbability of the truth of a particular superstition could the superstition be uprooted. It should be borne in mind that in those ages the single recognized purpose of the human reason was to apply the rules of deductive logic to premisses furnished by the Church, and to draw conclusions from them. All first and fundamental principles were provided by the Church and these were almost exclusively of *a priori* origin; inductive reasoning from attested facts was scarcely understood and was always strongly suspected to be tainted with Satanic suggestion. Uncompromising criticism of the first principles laid down by the Church could not be tolerated for a moment. Even to doubt them, even to raise a question concerning them, was sinful, for only by direct Satanic prompting could reason revolt against them or against conclusions strictly and logically drawn from them. Had they not come down direct from Heaven?

The complete change in public opinion about witchcraft was not brought about as the result of a controversy which completely settled the question and led to the formation of opinions which could be accepted by all enlightened men; rather it was brought about by what may be called the new spirit of the age. A gradual, scarcely perceptible, yet profound modification of European habits of thought began insensibly to prevail. It was not so much that new arguments were discovered during the decadence of the belief in witchcraft, it was rather that civilization was advancing and that the consequential changes were influencing public opinion. New intellectual tendencies modified the character of the public mind profoundly, and the new tone and habit of thought completely altered man's measure of probability. The Church had said, " You must believe this because the Church pronounces it to be true "; the answer had almost always been " I will steadfastly believe ", but now the answer was, " why should I? what is your reason, and what are the attested facts supporting it?" *

* Cf. Lecky, I, p. 133 *seq.*

For the first time for many centuries, a new spirit of doubt began to combat the old spirit of credulity, the old intellectual torpor began to pass away, and the long slumber of untroubled orthodoxy was broken by many heresies. The Church began to feel that the Devil had indeed been unchained.

The scepticism which had been smouldering for many years was first thrown into a systematic form by a very able and learned physician of Cleves, **John Wier,*** in his treatise *De Præstigiis Daemonum.* As a medical practitioner he was convinced that many of the witch victims were merely lunatics, and being a humane man he was greatly shocked at the sufferings they endured. He had not the slightest wish to free himself from prevailing modes of thought; in fact his reverence for authority would now be regarded as an infatuation. He was convinced that the world was peopled by vast numbers of invisible demons, and his only object was to reconcile his sense of their ubiquity with his persuasion that some of the phenomena that were deemed supernatural arose from disease. He expressed the view that the witches did not make an unholy compact with the Devil or become his concubines, but that the Devil had entered into them and was entirely responsible for their delusions. It was the Devil's purpose to throw suspicion on harmless old women who, themselves, were entirely innocent. Wier's treatise was prefaced by an earnest appeal to the princes of Europe to arrest the effusion of innocent blood.

Assuredly Wier's opinions did not in any way savour of audacity. In point of fact Wier formed a link between two periods, that of credulity and that of scepticism. Wier was as fully pervaded with the sense of the miraculous as his opponents, and never dreamed of restricting the sphere of the supernatural. In fact, in a later treatise, *De Lamiis,* he gives a detailed account of the organization of hell: there was a supreme council of 72 princes and 7,405,926 working evil spirits! Wier does not tell us whether he checked his figures after the first count!

* Cf. Lecky I, p. 85 *seq.*

But Wier had dared to attack received opinions, and a counter-attack was inevitable. **Bodin** * willingly lent himself to the task. He composed a scholarly work, *Démonomanie des Sorciers*, really an appeal to authority, though he also appealed to the popular belief in all countries, in all ages, in all religions. He showed how the laws of all nations recognized the existence of witchcraft. He related with the most minute and circumstantial detail, all the proceedings of the witches' Sabbath, their transformations, their carnal intercourse with the Devil, and their confessions when condemned. And that "puny doctor" Wier had dared to oppose himself to the authority of all ages, had showed a supreme contempt for the wisest of mankind, had reached the very climax of arrogance; his book was a tissue of "horrible blasphemies", and he had attempted to save those whom Scripture and the voice of the Church had branded as the worst of criminals. Far from relaxing prosecutions for witchcraft, it was now necessary to continue them with redoubled energy.—This precious treatise was published in 1581. Bodin was not, however, in any sense a natural bully. He was a profound philosopher and an extremely able and kind man, but he was utterly incapable of examining evidence objectively, and at the mere idea that "evidence" should be allowed to challenge an old belief he boiled over with indignation.

The age was still in no small measure spellbound by the fascinations of the past, but before the end of the same century, **Montaigne** (1533–92) † published the first great sceptical work in the French language, and, among the many subjects on which his scepticism was turned, witchcraft occupied a prominent place. But his treatment of the subject is in marked contrast with that of Wier and Bodin, both of whom had brought forward great masses of material from authoritative writers in support of the existence of evil spirits. Montaigne calmly and unhesitatingly discarded all such material; he had no sort of use for the miraculous, or for evil spirits of any kind. Theological measures of probability he discarded

* *ibid.*, p. 87 *seq.* † Cf. Lecky, I, p. 92 *seq.*

entirely and replaced them by shrewd and secular common sense. The statements of the witches he pronounced to be intrinsically incredible. "It is far less astonishing that witnesses should lie than that witches should perform the acts that were alleged." * Montaigne was the first French author to emancipate himself from the retrospective habits of thought that had so long been universal; to judge all questions by a secular standard, by the light of common sense, and by the measure of probability which is furnished by daily experience. He had obtained an intense perception of the fallibility of the human intellect and a keen sense of the absurdity of an absolute deference to the past. The bent and character of his mind forced him to believe that witchcraft was grossly improbable.

Had Montaigne lived a century earlier, his life would almost certainly have been forfeited, but the minds of men were now prepared for the reception of his ideas. A new school quickly arose; and a gradual destruction of the belief in witchcraft was effected, not by refuting or explaining its evidence but simply by making men more and more sensible of its intrinsic absurdity.

Another publication which had a far-reaching effect of the same kind was **Reginald Scott's** *Discovery of Witchcraft* (1584).† He unmasked the imposture and the delusion of the system with a boldness that no previous writer had approached. He exposed the atrocious torments by which confessions were extorted, the laxity and injustice of the methods of collecting evidence, and the egregious absurdities which filled the writings of the inquisitors. It was the ablest attack on the prevailing superstitions that had appeared. Another book which appeared about the same time was **Pierre Charron's** *De la Sagesse.* That which Montaigne had thrown into the form of strong doubt, Charron threw into the form of complete denial.

Naturally the Church hated all those signs of a rationalistic spirit and did its utmost to stem the advance of the new

* Montaigne, *liv.* iii, *c.* xi. † Cf. Lecky, I, p. 103.

movement. And throughout the seventeenth century, especially during the Commonwealth, prosecutions continued. But the new modes of thought slowly but steadily sapped the old belief. The movement was less one of argument or conflict than of silent evanescence and decay. The priests continued to exorcise the possessed, to prosecute witches, and to anathematize as infidels all who questioned the crime. But the sense of the improbability of witchcraft became continually stronger, till any anecdote which involved the intervention of the Devil was on that account generally ridiculed.

The last serious defence of witchcraft was made by **Joseph Glanvil** * (1636–80), rector of the Abbey Church, Bath, famous in his day as a dialectician and an accomplished scholar though something of a pedant. He rejected the scholasticism and Aristotelianism of his own university of Oxford and adopted the Platonism of Cambridge. It is a remarkable fact that the predominating characteristic of Glanvil's mind was an intense scepticism of a curiously limited kind, for he professed a profound distrust of the human faculties while not at all rejecting a distinct dogmatic system. On the strength of his first book, *The Vanity of Dogmatising* (1661), in which he painted in the darkest colours the "tenacity and inveteracy of prejudice", he was elected a Fellow of the Royal Society. And yet in a later book, *Sadducismus Triumphatus*, he entered a strong defence for the belief in witchcraft. He urged that there was such a thing as a credulity of unbelief, and that those who believed so strange a concurrence of delusions, as was necessary on the supposition of the unreality of witchcraft, were far more credulous than those who accepted the belief. It was because he so ingeniously made his scepticism his principal weapon that the book called forth the eulogies of such men as **Casaubon**, Dean of Canterbury, and **Cudworth**, the leader of the Cambridge Platonists. Even **Boyle**, a distinguished brother member of the Royal Society, wrote a compli-

* See Lecky, I, p. 110.

mentary letter to Glanvil, though it was expressed in very cautious terms. Replies to the *Sadducismus* appeared, but they proved to be unnecessary. Scepticism concerning witchcraft rapidly continued to increase, and eventually the superstition died.

The last witch trial was that of **Jane Wenham** * in 1712. The prosecutor was a Hertfordshire parson who declared "on his faith as a clergyman" that he believed the woman to be a witch. The judge entirely disbelieved in witches and treated the clergyman with scant respect, but the jury of ignorant rustics convicted the prisoner. The judge had no difficulty, however, in obtaining a remission of her sentence, greatly to the indignation of the local clergy. In 1736 the old witch laws were repealed, without difficulty or agitation, but as late as 1782 no less a man than **John Wesley** gave out that "the giving up of witchcraft is in effect giving up the Bible."† His words fell on deaf ears.

Lecky the historian says, "Witchcraft resulted not from isolated circumstances but from modes of thought; it grew out of a certain intellectual temperament acting on certain theological tenets, and reflected with almost startling vividness each great intellectual change. Arising amid the ignorance of an early civilization, it was quickened into an intenser life by a theological struggle which allied terrorism with credulity; and it declined under the influence of that great rationalistic movement which, since the seventeenth century, has on all sides been encroaching on theology. . . . When we consider the millions who have fallen in the religious wars, the countless martyrs who have perished in the dungeon or at the stake, the fate of a few thousand innocent persons who were burnt alive as witches seems to sink into comparative insignificance. Yet it is probable that no class of victims endured suffering so unalloyed and so intense. Not for them the wild fanaticism that nerves the soul against danger, not for them the assurance of a glorious eternity, not for them the solace of lamenting friends. They died alone, hated and unpitied.

* Cf. Lecky, I, p. 122. † *ibid.*, pp. 523–4.

All their sufferings were the result of a single superstition which the spirit of rationalism eventually destroyed."

But is the superstition of evil spirits *quite* dead, even now? We may relate an incident which occurred during the earlier years of the present century. It fell to the lot of a distinguished churchman, not a great scholar, formally to "open" a church for purposes of a certain ceremonial. Rather majestically arrayed, he solemnly walked up to the church door, struck it three times, and in a rather sepulchral voice cried out: "Avaunt, all evil spirits that have taken refuge in this holy shrine." It seemed to me it might be interesting to know what reaction these words had had on the listeners, and after the ceremony I questioned four of them. Here are their answers:

1. A boy of eighteen, then captain of a well-known Public School: "How did he know that the spirits could understand Shakespearian English?"

2. Another youth, a friend of the former: "How could the spirits *come* out? He hadn't opened the door. He would have shown more pluck if he had gone in and swished them out."

3. A prominent local professional man. "He merely wanted to give a thrill to the timid old ladies. He a believer in evil spirits! not a bit of it. I know him too well. I have, however, heard him, when badly bunkered during a round of golf, whisperingly complain to his Satanic majesty."

4. An elderly lady, known to be devout: "I didn't notice what he *said*, but how nice he *looked*. I am sure every woman there envied him."

The two schoolboys were, I knew, serious-minded, and in intelligence were well above the average. They were not naturally flippant, but their reactions to such an utterance on a solemn occasion were as unavoidable as they are forgivable.

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CHAPTER V

Perpetual Motion

1. Perpetual Motion: Natural and Artificial

In considering Perpetual Motion we must distinguish between: (1) classical physics, and (2) macro-physics and micro-physics; that is, between the physics of the laboratory and the physics of the telescope and microscope. It is true that the evidence we obtain by means of the telescope and microscope is mainly inferential, for by their aid we do not view the objects themselves but *images* of the objects, these images being formed by the light rays collected from the objects and concentrated into a focus by the object-glass, lens or mirror, and then magnified by the lenses of the eye-piece.* But, though inferential, much of the evidence is certain, and we need not hesitate to accept it.

In macro-physics, the physics of astronomy, perpetual motion is common enough, as we see from the motions of the sun, moon, planets, and stars. The earth was born at least a thousand million years ago, when a passing star lifted a tidal wave in the sun and was close enough to tear the tidal hump right away, and *ever since* it has obeyed the tangential pull then conferred upon it. How can a body once set in motion stop, unless something stops it? It was Newton himself who pointed this out so convincingly. But the earth has also ever since obeyed a second pull, the gravitational pull-back of the sun, and it travels round in its elliptical orbit in obedience to the resultant of the two forces upon it. The

* There is, of course, a more primary image, viz., that formed on the retina of the eye.

motion is certainly "perpetual" enough to last at least hundreds of millions of years more, secular variations notwithstanding. As for micro-physics, it is now generally accepted that the planetary electrons of the atom are in perpetual motion and must so continue as long as the atom exists, perhaps for myriads of years. And those who have watched the Brownian movement under the microscope—the ceaseless movement of tiny particles, say of a gamboge solution, held in suspension in a fluid at a uniform temperature—will scarcely venture to deny the possibility of perpetual motion, though it must, of course, be admitted that such a movement of microscopic particles does not enable us to derive useful work from the heat agitation of the liquid, that is, from the perpetual motion of the molecules themselves.

Laboratory physics with which we are all so familiar is something altogether different, for then we are in close contact with ordinary controlled experiments which provide us with inescapable facts from which we generalize and establish our laws. In the laboratory we find it utterly impossible to construct any sort of machine providing perpetual motion. True, we seem sometimes to come very near it when in particular ways we utilize natural forces. For instance, as long as the Niagara Falls last we may safely assume that they will, if we wish, continue to drive turbines for the huge electrical generating station at their foot. Again, it is a simple matter to construct a clock which will "go" for an almost indefinite period; a minute supply of electric energy is sufficient. Even an ordinary barometer is virtually an example of perpetual motion, for it is very doubtful if the pressure of the atmosphere is ever absolutely constant for an appreciable time. For driving such machines, if machines they may be called, evidently we either use natural forces or we supply the necessary power artificially.

The perpetual-motion machines which inventors have for ages tried to construct and make to work are altogether different in principle from such types as those to which we have just referred. They are always supposed to be machines

which, once started, will run for ever, in some way providing their own power, their designers knowingly or unknowingly stealing the power from gravity or some other natural force, but probably claiming to be creating it out of nothing. A perpetual-motion machine usually signifies, then, a machine which will create energy and reveal it in the form of motion. Its inventor almost always claims to *create* energy, and thus to add to the world's existing supplies of energy. He therefore flouts, as we shall see, two of the most definitely established principles of physical science.

2. Some Perpetual-Motion Machines

The commonest device of the perpetual-motion makers was a wheel of some kind, a wheel which was usually described as "over balanced" because of some scheme of movable weights attached at equal intervals to the rim. The earliest authoritative record is attributed to a Gothic architect, **Vilard de Honnecourt,** whose very crude sketch shows an odd number of mallet-shaped weights attached to the rim by hinges at the ends of the mallet handles. Apparently the mallets were to fall over always in one direction and so keep the wheel revolving (fig. 6). De Honnecourt's sketch-book is still preserved in the Écoles des Chartes at Paris. De Honnecourt says, "many a time have skilled workmen tried to contrive a wheel that would turn of itself: here is a way to do it by means of an uneven number of mallets, or by quicksilver."

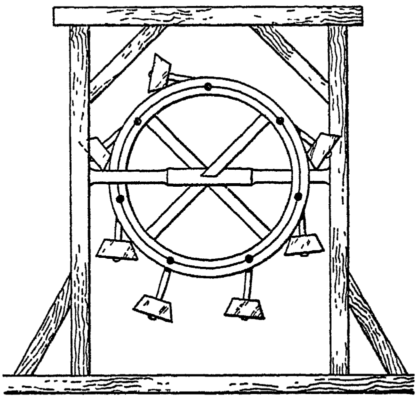

Fig 6—Honnecourt's overbalanced wheel

Fig. 6 shows the designer's own sketch; fig. 7 shows more clearly the designer's probable intention. On the one side of the wheel the weights rest tangentially; on the other they are thrown out radially. When the wheel turns in the direction *a*, *b*, *c*, the weights A, B, and C will recede from the centre, and will therefore tend, it is argued, to overbalance the weights hanging on the opposite side. As the wheel revolves, a new mallet will be thrown out radially, and this will go on indefinitely. From this specious reasoning

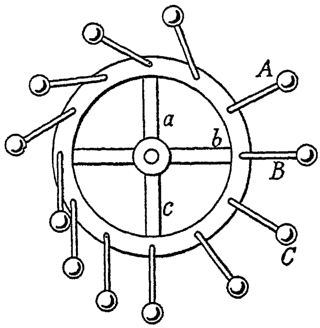

Fig 7

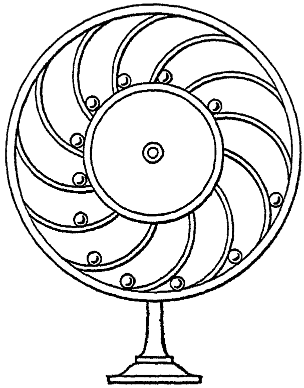

Fig. 8

we are to infer that the centre of gravity of the system is kept to the right of the centre of rotation!

Another variety of the same principle is shown in fig. 8, which probably represents, diagrammatically, the wheel designed by the Marquis of Worcester (*d.* 1667). The Marquis alludes to the wonderful performance of the wheel in his *Century of Inventions*, 1663. The wheel was 14 ft. in diameter and contained 14 iron balls of 50 lb. each. The idea was that the balls rolling within the compartments between the felloes and the rim would, as a whole, so comport themselves that the leverage about the centre of those on the descending side would exceed the leverage of those on the ascending side. It was argued that since the balls on the

right-hand side are farther from the centre than those on the left-hand side, their turning effect must be greater, and the right-hand side of the wheel will always go down of its own accord. But there are always more balls on the left-hand side, and when the turning effects of all the balls are taken into account there is an exact balance. Clearly if we give the wheel a complete turn, so that each ball returns to its original position, the whole work done by the ball will, at the most,

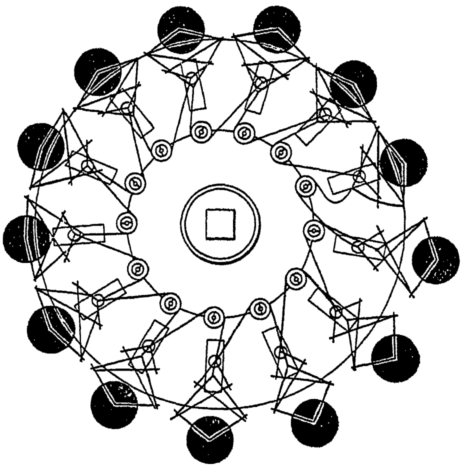

Fig. 9.—A more elaborate type of perpetual motion machine

be equal to that done on it. It is impossible for the system ever to gain energy during its motion. Actually the wheel would run better without any balls, for the rolling about of the balls produces a little extra friction.

Fig. 9 shows a more elaborate application of the same basic principle. The black discs represent weights which are pushed farther out on one side than on the other by a complicated system of cords and pulleys. This case is even more impossible than the last, because of the much greater amount of friction. If the weights were actually screwed into position, the machine would continue to work for a longer time.

Fig. 10 is taken from Montucla's edition of Ozanam's *Recreations in Natural Philosophy*. The machine is practically the same as that in fig. 8, mercury being substituted for the iron balls.

Fig. 11 is also taken from Ozanam. Each of the eight radial arms of the wheel is furnished with a bellows-like receptacle, the opposite arms being turned in opposite directions. To the flexible top of each receptacle is attached a weight which in one position tends to close the receptacle and in the opposite position to open it. Each opposite pair

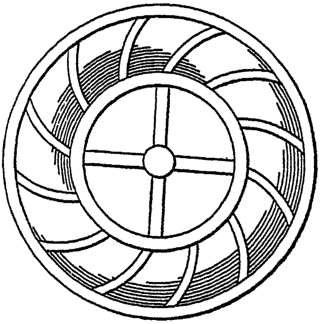

Fig. 10.—Ozanam

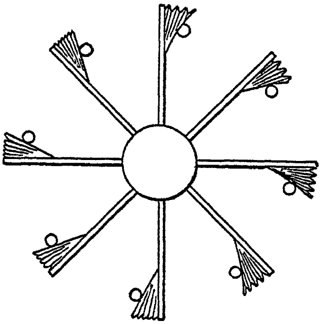

Fig 11.—Ozanam

of receptacles is in tubular communication, and within these is a quantity of mercury which flows backwards and forwards. Needless to say the wheel is as great a failure as the others, and for the same reason.

Other would-be inventors of perpetual-motion machines have resorted to the Archimedean screw, a machine which, it is believed, was invented by the famous Greek, **Archimedes**, for the purpose of removing the water from the hold of a large ship which had been built by Hiero, King of Syracuse. Varieties of the machine are still used in Holland. It consists of an inclined water-tight cylinder which encloses a screw arranged in such a way as to form a spiral chamber from end to end. The lowest portion of the screw just dips into the water, and as the cylinder is turned once round, water is

scooped up to the height of one thread of the screw. A second revolution, and the water rises another thread, and so on,

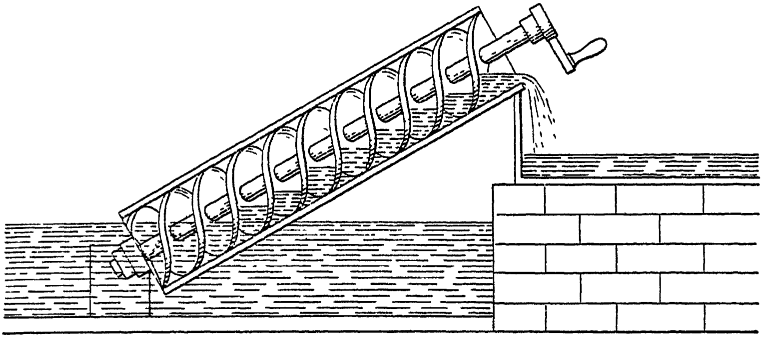

Fig 12 —Archimedes' screw

until at last the water emerges at the top of the cylinder. The water is lifted mechanically, and the water poured out is a measure of the work done by the operator. Fig. 12 shows a section of one form of the screw. Perpetual-motion inventors tried to make the screw work automatically. They encircled the cylinder with a series of wheels ringed round with vanes. When the water was discharged at the top of the screw, it was made to flow upon the vanes of the uppermost wheel; it was then caught in a second vessel and then made to flow in the vanes of the second wheel: and so on (fig. 13). It was claimed that this succession of operations would readily suffice to keep the

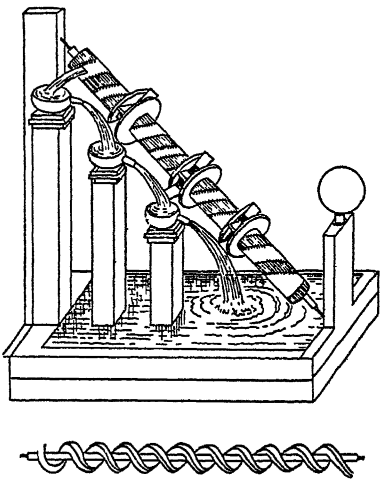

Fig 13 —Attempt to use Archimedes' screw for perpetual motion

machine in perpetual motion. But the machine would not work!

A more naïve device is shown in fig. 14. It was gravely argued that since the weight of the water in the larger part of the vessel is greater than that in the smaller part, it must "over balance" the latter, and bring about a perpetual overflow at the orifice C!

The vain quest has been extended even into the field of capillary attraction. It was argued that if by capillary attraction water can be made to disobey the law of never

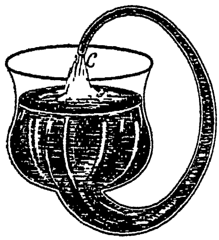

Fig. 14

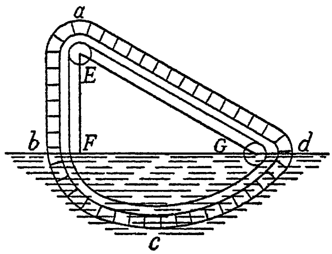

Fig 15

rising above its own level, what can be easier than utilizing the principle for making a perpetual machine? Perhaps the best-known of such machines is that due to **Sir William Congreve** (1772–1828).—An endless band of sponge *abcd* (fig. 15) travels round an inclined plane EFG, and over the sponge is an endless uniform band of heavy weights, jointed together. A vessel of water is arranged as shown in the figure. By capillary action the water rises in *ab*, but this cannot happen in *ad* since the weights squeeze the water out. Hence, inch for inch, *ab* is heavier than *ad*. But the Dutch mathematician, Stevinus, proved three or four centuries ago that if *ab* were only just as heavy, inch for inch, as *ad*, there would be equilibrium. Hence the extra weight in *ab* ought, it was argued, to cause a motion of the bands in an anti-clockwise direction, and this motion would be perpetual. But even this machine refused to work!

Bishop Wilkins of Chester, in his *Mathematicall Magick* (1648), refers to attempts to discuss perpetual motion in the domain of chemistry, but the accounts are obscure. He also refers to the use of magnetism for the same purpose. It is scarcely necessary to say that electricity has also been utilized, and, in more recent times, liquid air.

Not all perpetual-motion would-be inventors are mere simple-minded visionaries. A few have been men of recognized intellectual eminence, who have become obsessed with the idea that perpetual motion is possible. It is even said that **Leonardo** himself (a universal genius, if ever there was one) " dabbled " in perpetual-motion schemes. **John Bernouilli** the elder, one of the most famous of European mathematicians, was certainly caught in its toils. His demonstration of the principles involved in the working of his machine (which was quite simple—two cylinders, two liquids of different densities, and a filtering separator) is a model of mathematical logic, but his ignorance of the simplest principles of practical hydrostatics was abysmal. His conviction that a workable machine can be constructed from mathematical symbols probably died hard.

3. Perpetual-Motion Charlatans

There was another type of perpetual-motion claimant, not the untrained simpleton, not the obsessed mathematician, but the charlatan; occasionally he was an ignorant conceited nobody anxious to show the world that he was somebody; more often he was an impudent impostor who thought he could see his way to making a fortune out of the gullible multitude.

One of the former was **Orffyreus (Johann Ernst Elias Bessler)** (1680–1745). He constructed a wheel 12 feet in diameter and 14 inches broad, the spacious interior being carefully concealed by an oilcloth covering, and it was mounted on an axle which had no visible connexion with anything

outside. It is said to have been in action for two months in a sealed room belonging to the landgrave of Hesse-Cassel. The mathematician W. J. s'Gravesande became interested but was not allowed to examine the interior, and it is said that eventually the inventor destroyed the machine because of s'Gravesande's " impertinent curiosity ".

Charles Redheffer, an American, exhibited a machine in Philadelphia in 1812–13. It attracted universal attention, but at last it was discovered that the machine was secretly connected up by catgut to another room where an old man was employed to keep an auxiliary machine in motion. Redheffer was a rank impostor.

Another Philadelphian, **John W. Keeley** (1837–98) invented a perpetual-motion " motor ", and he contrived to induce a number of simple-minded capitalists to form the Keeley Motor Company in New York. He called his machine a " hydro-pneumatic-pulsating-vacuo-engine ", and used such high-sounding terms as " quadruple negative harmonies ". Keeley fooled everybody and made a fortune. It was not until after his death that the entirely fraudulent nature of his machine was discovered. The remarkable performances of the complicated machinery which had so impressed a credulous public who had paid their dollars to watch them had been controlled from a cellar, where the necessary motive-power had been installed!

This kind of rogue is still with us, but these are days when he has to walk very warily. He no longer claims to be able to create energy out of nothing; indeed he begins by pointing out to those whom he hopes to make his dupes that such a claim would be childish and absurd. The machine he tries to sell is, perhaps, a machine which requires to be fed by a small electric current off the main, but which will then, so cunningly has it been made, appear to give out twice, or it may be even three times, the power it has taken in. It is the extreme modesty of the claim that is so apt to " take in " a doubting purchaser.

It is a remarkable fact that the great majority of the

earlier perpetual-motion claimants always seemed to invent some excuse for not actually producing an actual working model of their machine. Complete specifications and drawings were invariably produced, but never a machine that would work. They were afraid, they said, that they would be robbed of their idea and therefore of the fruits of their life's work if a completed model was shown. Never was a machine seen " going ". " If you think the machine when made will not work, give me your reasons " In this way doubters were generally silenced, for in those early days the " conservation of energy " was a principle not yet established, and a satisfactory answer was difficult to give.

4. Conservation of Energy

" Conservation of Energy ": what does it mean?

It is only within the last century or so that the making of a perpetual-motion machine has been definitely shown to be impossible. Really this was due to the research of eminent physicists whose work eventually led to the universal recognition of a new principle, the " Conservation of Energy ". The nature of energy is by no means easy to understand completely, especially by the non-physicist and non-mathematician, but even an elementary account of it may serve to throw a good deal of light upon the subject of this chapter.

Whenever a mechanical force acts in such a way as to make a body *move*, *work* is said to be done by the agent which produces the force. Thus, a man does work when he drives a spade into the ground, and a steam-engine does work when it moves a train. Mere force apart from motion does no work; a weight resting on a table exerts a pressure but it does no work. Again, mere motion apart from force does no work; when a ball is thrown along a surface of smooth ice, work has to be done to give it a start, but, after that, the ball would go on moving for ever if the ice surface were perfectly horizontal and unlimited in extent, if the surfaces

of the ice and ball were perfectly smooth, and if there was no air resistance or any other kind of opposing forces. For what could stop it? This is really Newton's First Law of Motion. Of course the motion which results from expenditure of work is not always *bodily* motion. If we file a piece of iron which is fixed in a vice, the iron does not move from its place, but it gets hot; there is *molecular* motion, and *heat* is produced.

Whenever anything has the power of doing work, it is said to possess **energy**. When a grandfather clock is wound up, the weight is given the power of driving the clock and so of doing work, that is, it possesses *energy*. The energy is due to the fact that the weight is *raised*, for after the weight has run down it can no longer drive the clock. It is *energy due to position* (potential energy). When a locomotive draws a train, it is doing work, that is, it possesses energy, but the *energy is due to motion* (kinetic energy). When a stone falls from a height, it starts with a certain amount of *potential* energy; as it descends, this gradually disappears, being transformed into *kinetic* energy. Just as it touches the ground, the energy is all in the kinetic form, and after it has struck the ground all this bodily kinetic energy is changed into *heat*, that is *molecular* energy. *Throughout these changes there is neither creation nor destruction of energy*; the whole of the energy has been conserved, but it has not been increased.

In a switchback railway, if there was no friction and no atmospheric resistance, the car would climb to the same height as that from which it started. To overcome these opposing forces, the attendant gives the car an initial push. So with the pendulum; a clock stops as soon as the spring or the weight ceases to pull.

Energy is thus the capacity to do work, and we measure it by the amount of work which the agent concerned can do. A man who lifts up a 50-lb. weight through a height of 3 ft. is said to do (50 × 3) "foot-pounds" of work. But the man may work quickly or slowly, and we always want to know the *rate* at which he or any other agent (an engine, for instance)

works. Engineers use the term *power* to signify the *rate of doing work.* An engine of *one horse-power* is one that can do 33,000 foot-pounds in one minute. A horse is supposed to be able to work at the rate of 550 foot-pounds per second, that is, to raise 550 pounds through 1 foot in 1 second or 2200 pounds (nearly a ton) through 1 foot in 4 seconds or 1 ton through 15 feet in 1 minute. A *kilowatt* * is the electrical engineer's measure of power, and his unit of time is the *hour*, so that electrical energy is often spoken of in terms of *kilowatt-hours.*

The world's supply of coal and oil represents great stores of energy, but the supply is certainly not inexhaustible. Nature's vast stores of energy are also manifested in other ways, in moving air, in moving water, in the sun's heat. The water-power of rapid rivers and waterfalls has been utilized on a large scale; for instance, 500,000 horse-power are generated by water turbines at the foot of Niagara. The energy of ocean currents, tides, and waves, is enormous, but it is spread over such vast areas that in practice it is virtually impossible to harness it. Here and there the energy of tides may be used by constructing dams across tidal rivers and then utilizing the energy thus stored for driving water turbines. Vast supplies of solar energy are received by the earth, but the amount available from any really manageable area is relatively small, and the collection of the solar rays on a scale large enough to drive a useful engine is, as a rule, impossibly costly. The best known solar engine is in use near Cairo. Nature's most bountiful supply of energy is the energy stored away in the nucleus of the atom, but we

* A kilowatt = 1000 watts; a *watt* is the power delivered by a current of 1 ampere conveyed under a pressure of 1 volt. (1 kilowatt = $1\frac{1}{3}$ horse-power)

The layman is apt to confuse even well-known electrical terms —If water is delivered through a small pipe, its easy flow is obstructed, the delivery is small because the water has to force its way along against the obstructing resistance, but we could increase the flow either by increasing the size of the pipe or by driving the water along under pressure. So with electricity. electricity conducted along a very thin wire experiences a resistance to easy flow, with a thicker wire the resistance is reduced. But we may also drive the electricity harder, that is, subject to the greater *pressure*. The unit of current is called an *ampere* (that is the quantity of stuff delivered, whatever sort of stuff electricity may be), the unit of pressure is called a *volt*, and the unit of resistance the *ohm* We may think of a *watt* as the rate at which work is done by one ampere flowing through one ohm.

know of no means of releasing it, except on a very minute scale. Our ordinary disruptive agents of the laboratory, viz. great pressures and high temperatures, do not affect the atom in the slightest degree. The physicist can separate the molecules of a substance easily enough, the chemist can separate the constituent atoms of the molecule easily enough, but the atoms themselves defy both physicist and chemist—at present.

When two surfaces rub each other, either by a rolling or by a sliding movement, the force of friction is produced. Friction is an *opposing* force, its tendency always being to prevent easy movement. The absence of friction sometimes puts us at a disadvantage, as when we try to walk over a polished floor. But if there was no friction, no car could travel along the road or train along a railway, unless down hill, and then it could not stop.

We diminish friction in machines by lubricating the rubbing parts, the bearings. Friction at a bearing has two disadvantages: (1) work has to be done to overcome it, (2) it makes the bearing *hot* and the metal may be injured.

Rolling friction is less than sliding friction. The old-fashioned cast-iron "shoe" put under a wagon wheel during the descent of a hill prevented the revolution of the wheel, but despite this kind of efficiency it played havoc with the road surface and became extremely hot. In certain types of wheels, the ordinary bicycle wheels for instance, friction is greatly reduced by the use of ball-bearings—a ring of hard steel balls enclosed in a sort of cage round the axle; the surface areas in contact are reduced to a minimum and the rolling is very free.

Friction invariably produces heat, and this may be very considerable The energy which is thus "lost" and has apparently disappeared in overcoming the friction has been *changed into heat.* We ought not to say that some of the work done is "lost" owing to friction but that it has been converted into heat. *Heat is a form of energy.*

The English physicist, Joule, showed conclusively by many experiments that when mechanical work is turned into

heat, or when heat is turned into mechanical work, no matter how the exchange is effected, a certain fixed quantity of work always produces the same quantity of heat, and vice versa; the ratio of the quantities is invariable.

It is a familiar fact that we often change heat into work. That is what a heat-engine is for, whether of the external or the internal combustion type. By keeping the furnace going, we supply the engine with heat, and in return the engine does work.

During the latter half of the nineteenth century, the researches of Joule, Hirn, Kelvin, and others, placed on a firm basis the Principle of the Conservation of Energy. This principle is far-reaching. It implies that underlying the phenomena of mechanics, heat, electricity, magnetism, light, and all forms of radiation, there is something fundamental which is common to them all, that all those phenomena are merely different manifestations of the something we call *energy*, something which can neither be created nor destroyed. The different forms of energy are mutually convertible; if one form of it disappears, a corresponding amount of another form appears and takes its place. As applied to heat the principle is called the First Law of Thermodynamics, which may be stated thus: *when heat is transformed into any other kind of energy, or when any other kind of energy is transformed into heat, the total quantity of energy remains invariable*; in other words, the quantity of heat which disappears is equivalent to the other kind of energy produced, or the quantity of any other kind of energy which is used up is equivalent to the heat produced.

There is, however, an important distinction between heat energy and other forms. We can carry out processes by which any one of these latter forms can be completely converted into any other or into heat, but our powers of converting heat into other forms are limited.

Heat can be converted into mechanical work only when it is conveyed from a body of high temperature to one at a lower temperature. We can never make the boiler of an

engine as hot as the furnace. If the whole earth was at a uniform temperature, say 105° C., we should have an abundance of steam, but we could not make an engine work because of the lack of a lower temperature. Similarly, if all the water on the earth were at the same level we could not work a water-wheel. The analogy is exact.

Since we can never convert into work the whole of an available supply of heat, we must regard heat energy as of a lower grade than the energy of other forms. The fact that we are not free to use the whole of it is stated in the Second Law of Thermodynamics, a law which is expressed in several ways. The German physicist, Claudius, expressed it thus: *It is impossible for a self-acting machine, unaided by external agency, to convey heat from one body to another at a higher temperature*; *or*, *heat cannot pass from a cooler to a hotter body*. It is true that this second law has never been formally proved, but all physicists are convinced of its truth because it has been confirmed by countless experiments and never contradicted by one. Moreover, predictions based on it have always been found to be correct.

The law is really very simple. Imagine a sealed chamber, unaffected by outside bodies, at a temperature say, of 80° C. Obviously it contains plenty of heat. Into it introduce a cold body, say one at 5° C. The temperature of the chamber will fall and that of the cold body will rise until both are at the same temperature, say 70° C. The cold body contained *some* heat to begin with, keeps it, and takes more. Now imagine a hot body, say one at 300° C. put into the same chamber, at 80° C. as before. The temperature of the chamber will rise and that of the hot body will fall until both are at the same temperature, say 95° C. This time the chamber does not part with any of its original heat but keeps it, and takes more.

It is not impossible, of course, to transfer heat from a body to another of a higher temperature, but, to do so, energy from some outside source must be supplied. As the second law states, " a self-acting machine unaided by external agency "

is, for such a purpose, useless. Whenever two bodies at different temperatures are left together, the hotter one invariably gets colder. The greater the difference of temperature between them, the greater the fraction of the heat of the hotter body we can turn into work.

Since there is a constant tendency for heat to pass from places at higher temperature to those at lower temperature, there is a *degradation of energy*. And since in any actual conversion of energy from one form to another a certain amount is inevitably wasted, for example by friction, the wasted energy being converted into heat, such a conversion is spoken of as *dissipation of energy*. Thus the energy of a system is always becoming less available for general use.

Despite the laws of thermodynamics the perpetual-motion would-be manufacturer argues as if he thought the store of energy in the universe could be increased. It is because he so completely fails to understand the laws that his reasoning always seems to be so irrational and that he continues to pursue the phantom.

When the Law of the Conservation of Energy was formulated, it was also believed that *matter* could neither be created nor destroyed; there was thus another law, that of the conservation of matter. The equivalence of matter and energy was then hardly suspected. The atom is now known to consist of different kinds of particles, just charges of electricity, and even the most die-hard chemist now cheerfully admits the possible extinction of the atom. The law of the conservation of matter has now dropped out of science, and we now speak of the principle of *the conservation* of *mass and energy* jointly, for it is now definitely known that, fundamentally, mass and energy are identical. Energy of every kind has a mass of its own. A 30,000-ton battleship going at full speed would increase its weight: it is true that the increase would be very small—a scarcely measurable fraction of an ounce, but of the reality of the increase there is now no doubt at all.

In view of the quite definitely limited supply of matter and energy in the universe, and of its slow but inevitable degradation and dissipation, how will the universe end? Is the perpetual-motion manufacturer of the far future likely to achieve success?

5. The Store of Energy in the Universe

If the reader is to obtain some faint idea of the vast store of energy in the universe, he must first try to gauge the actual extent of the universe, so far as we know it at present. The knowledge has been derived largely from researches in American observatories, the wonderful 100-inch reflecting telescope at the Mount Wilson observatory in California having played a leading part in such researches. A 200-inch telescope is now in course of construction, and when the instrument becomes available for use, our knowledge of the universe will probably far exceed the limits outlined in the next few paragraphs.

The arithmetic concerned is of the first importance; it is very easy.

Laboratory experiments tell us conclusively that ordinary light travels at the rate of 186,000 miles a second. It therefore takes rather more than 8 minutes to cover its journey of 92 million (92,000,000) miles from the sun to the earth. The distance it travels in a year is evidently about $186{,}000 \times 60 \times 60 \times 24 \times 365$ miles, that is about 6 *billion* miles.* This distance of 6 billion miles is the astronomer's unit distance and is called a "light-year", i.e. the distance *light* travels in a *year*. To form a conception of this vast distance requires a considerable effort, but the effort should

* A billion is a million millions, i.e. $1{,}000{,}000 \times 1{,}000{,}000$ or $10^6 \times 10^6$, or 10^{12}. A trillion is 10^{18}, a quadrillion is 10^{24}; and so on. But in the U S A. and in France, a billion is a thousand millions (10^9), a trillion is a thousand billions (10^{12}), and so on. The terms are therefore apt to be a little ambiguous, and the index notation should always be added as a check.

be made.* It is as familiar to the astronomer as the foot is to the builder or the chain to the surveyor.

The number of stars which can be seen by the keenest unaided eye on a clear moonless night is—how many? Not millions, but only about 3000. The smallness of this number may be easily gauged by remembering that a watch ticks 3000 times in 10 *minutes* But with a small telescope a much greater number of stars may be seen, and with a powerful telescope, especially with a camera adjunct, the number of stars seen is so vast that the mind almost reels in the attempt to overcome its natural incredibility. But this vast number is not scattered all over the sky, as the 3000 easily seen stars might suggest. For the most part they occupy a particular region which, in point of fact, is indicated by the "milky way", an enormous faint circle of light extending right round the heavens; on a clear moonless night, half of it may easily be seen in the northern hemisphere, and the other half in the southern hemisphere.

The Milky Way is technically known as the "Galaxy" and it is in that part of the heavens where the vast majority of the stars are to be found. Roughly the galaxy has the shape of a disc, something like two plates edge to edge. According to the view of Professor Shapley, the eminent astronomer, the diameter of the disc is about 300,000 light-years,† and its thickness about 10,000 light-years. The number of stars in the galaxy is about a hundred thousand million (10^{11}). Our sun is one of this number, but he is by no means in the centre of the galaxy.

The reader who is unversed in modern astronomy may be a little startled to learn that our own galaxy, almost immeasurably vast and almost unimaginable as it is, is but an utterly insignificant island in the universe as a whole. The telescope and camera have long shown us vast numbers of two-armed spirals of incredibly distant tiny clouds of light,

* Simple arithmetical illustrations may be easily thought out. For instance, an ordinary watch ticks 5 times a second, to tick a billion times it would therefore take 6000 years.

† Nearly 2 trillion miles.

and these we now know to be other galaxies, much the same as our own. Sir Arthur Eddington gives us the following "multiplication table".

A hundred thousand million stars make one galaxy.
A hundred thousand million galaxies make one universe.

Thus the total number of stars in the universe is about (100,000,000,000) $\times$ (100,000,000,000), or $10^{11} \times 10^{11}$, or 10^{22}, i.e. ten thousand trillion.

These figures may make a very small appeal to the reader who does not care for mathematics. If so, here is an alternative method of stating the same fact: Let the individual stars be represented by single "drops" of water, the "minims" of the pharmacist's prescription. The 3000 drops of water representing the 3000 stars visible to the unaided eye in the northern hemisphere, *would not fill an ordinary tumbler*; the 10^{22} drops representing the 10^{22} stars in the universe are just about equivalent *to all the water in all the oceans of the world.* And yet the stars are at such great distances that *each one has billions of cubic miles of space to roam about in.* The very nearest to us is no less than 4 light-years (24 billion miles) away.

The galaxies are anything from 1 million to 200 million light-years distant from us, and the distances are rapidly increasing; doubling, in fact, every 1300 million years. This is sometimes spoken of as the "expansion of the universe". It would be more accurate to speak of the "recession of the galaxies".

Can we form any conception of the vast store of energy within the universe?

Let us consider the star we know best, our own sun, by no means the most conspicuous instance in size or magnificence.

The diameter of the earth, one of the sun's children, is 8000 miles, and that of the sun himself 100 times as great, i.e. 800,000 miles. The volume of the sun is thus a million

($= 100^3$) times that of the earth. The surface temperature of the sun is 6000° C., much higher than the melting-point of carbon; at the centre, the temperature is no less than 40,000,000° C., a temperature at which no molecules can possibly exist and at which even their constituent atoms are disrupted into their own constituent particles. *Every square foot* of the sun's surface is radiating energy at a rate of *a 9000 horse-power engine*, but the proportion of this radiation which the relatively insignificant earth receives (its surface-area is only one ten-thousandth that of the sun) is only 1 part in 2,200,000,000. Yet the energy which the earth thus receives in the form of solar radiation amounts to nearly 5,000,000 horse-power per square mile of surface.

By thus radiating energy, the sun loses *4,000,000 tons of its mass every second.* But its total mass is known to be about 2000 quadrillion ($2000 . 10^{24}$) tons, and therefore in a billion (10^{12}) years about 5 per cent of the whole will have radiated away; by that time life will not be so tolerable on the earth as it is now, though doubtless it will have adapted itself to the colder conditions. If the present rate of radiation persists, the whole sun will have disappeared in about 20 billion years. The sun was formerly much heavier; apparently, therefore, its substance *must* have radiated away; its atoms *must* have been annihilated.

So far, however, we have spoken of only a single star. Not all stars are of the same age: some are old, some are young. But the same general argument applies to them all: they are radiating away their substance; they are cooling down; they are all dying, despite the vigorous life many of them are still showing.

In the interior of each star are two vast opposing forces. The temperature, say 40,000,000° C. tends to bring about disruption, a violent explosive dispersal outwards; but this does not happen. The star is held together by gravitation; the resulting inward pressure is equal to 40,000,000 atmospheres. This inward pressure suffices to overcome the tendency to outward dispersal.

The energy within a single atom is enormous. Could we release it and utilize it, that from a single ounce of coal would be enough to drive every train in Britain for a whole year. At the enormous temperatures in the interior of the stars, a great deal of the atomic energy is bound to be released, for the constituent particles of the atoms cannot, under such conditions, be possibly held together. There can be little doubt that amongst the protons and electrons, respectively positive and negative charges of electricity, there is often a coalescence and neutralization: there is a flash, and a little packet of light is formed; matter has been transformed into radiation; the fused proton and electron have become a "photon", which rushes away as a wave; the "bottled up" congealed stuff we call "matter" has become unbottled and is forced to radiate away as light waves. But the quantity of the activity in the universe has not been modified, only the *quality*. The sum total of the quantity of activity—energy or mass or whatever it be called—is constant. The joint conservative law of mass and energy is strictly obeyed.

Let us make our way backward in time. How did the universe "begin"? It is believed * that the galaxies are receding from one another, and that at one time they were much closer together. The hypothesis now almost universally accepted is that they all originated in one vast nebula, which filled the whole of the interstellar space we know. When we remember the weight of a single star, and the vast number of stars, we realize that the amount of matter in the original nebula must have been stupendous indeed. Even so, there could have been *only about six atoms to a cubic inch* of space! (Some idea of this amazing tenuity may be obtained from the fact that if a wineglassful of water were thrown into the Atlantic Ocean and complete diffusion took place, a glass of water drawn out from any part of the ocean would contain *two or three hundred molecules* of the original glassful.) This great nebula may have existed for an indefinitely long time,

* For the evidence of this and for the deductions drawn from it, see the author's *The Endless Quest*, pp 623 *seq.*

but if by any means one part became ever so slightly denser than the rest, gravitation would set in, there would be condensation in that region, heat would be produced by the contraction, and a grand start made. But why that slightly greater density in one place? Sir James Jeans suggests that the nebula may have been agitated by "the finger of God". That assumption granted, the subsequent evolution of the universe would take place in accordance with natural laws. There may have been, almost certainly were, grand-scale cosmical catastrophes during the process, but the process went inevitably on. In due course the earth was born, and so was man.

Now let us make our way *forward* into time, say 40 or 50 billion years. Will the stars have cooled down and have become greatly shrunken, dense, excessively cold, solid globes wandering about in space? Science is against such a supposition, but, even if it happened, the stellar collisions which by the laws of probability would sometimes take place, would lead to a new production of heat and thus to a new start of some kind. Much more likely, however, is the complete annihilation of matter. Just as an ordinary fire burns itself out, so the stars may burn themselves out, only much more effectually. In that case there would be not only an annihilation of matter but also a gradual degradation of energy. Less and less energy would be available, and eventually there would be universal thermodynamic equilibrium. All energy would have been transformed into heat of a very uniform temperature. Nevertheless, energy of a low grade would survive. Though now quite useless, its absolute extinction is unthinkable.

The opinion of some leaders of science is that the universe is bound to end in this way. "The universe will simply go out." But not a few others refuse to share this view. The evidence for the recession of the galaxies is not altogether convincing, and even if there be a recession at present, the recession may not be permanent. There are stars commonly referred to as "Cepheids", so-called because the first one

to be discovered was the star Delta in the constellation *Cepheus*. These stars are characterized by a remarkable periodic variation of brightness; δ *Cephei* itself has a period of $5\frac{1}{3}$ days. During this period it increases in brightness and then decreases. The amount of variation is startling and it is absolutely regular. It almost suggests the gradual turning down of a huge gas-tap, and then its sudden turning up again; it is almost like a breathing thing, regularly inspiring and expiring. What is it? We simply do not know, but such stars are very common. Some astronomers ask, if single stars pulsate in this way, may not the whole universe pulsate similarly? If the galaxies are now receding, may they not some day reverse their motions, just as the Cepheids do? Professor Millikan is one of those who refuse to believe that the universe is likely to run down finally. If a start was made once, why should it not be made again? Perhaps he is an optimist. Sir Arthur Eddington and Sir James Jeans seem to be convinced that the final death of the universe is certain: are they therefore to be called pessimists? At the back of their minds are the laws of thermodynamics and the admitted impossibility of constructing a perpetual-motion machine. If the universe is really "running down", we are bound to deny that even nature herself is really an example of perpetual motion.

Quite obviously we must suspend judgment. The indisputable evidence which is available is admittedly slight and is altogether inadequate. At the best our laboratory experiments are on a very small scale, very far removed from nature's large-scale methods of working. The speculations of even our ablest physicists and astronomers are necessarily a little rash, but how dull we should think men of science if they confined themselves to cold facts and never hazarded a guess at possible explanations. How the universe originated, we really *do not know*; how it will end we certainly *do not know*. But one thing we do know, and that is that *no perpetual-motion machine has ever been invented*; *and we believe such an invention to be impossible,* for our knowledge of

science, fragmentary as it is, compels us to believe that nature's stock supply of energy cannot be increased, even in the smallest degree, by any kind of human agency.

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CHAPTER VI

Squaring the Circle

1. The Problem

"*A horse is tethered to a stake in the hedge of a circular field* 100 *yards in diameter. What must be the length of the tether in order that the horse may be able to graze over exactly one-half of the field? (The length of the horse's body may be ignored.)*"

An innocent-looking problem! Actually, it is a problem which cannot be attacked with any chance of success except by a competent mathematician, and even he will fail to find a solution, because the problem is really insoluble. A solution to any required degree of approximation may be found of course, but such a solution will *never give an exact fraction of* 100 *yards*. The ratio of the length of the tether to 100 yards cannot be expressed as a vulgar fraction consisting of two whole numbers, no matter how large the numbers may be.

The problem is not the famous circle-squaring problem, but it is a first cousin to it. The circle-squaring problem is one of three which have come down to us from classical times, and, for nearly 3000 years, mathematicians have been wrestling with them. They are: (1) to trisect an angle; (2) to construct a cube of twice the volume of a given cube; and (3)—the most famous—to construct a square equal in area to a given circle. It is with the last that we are concerned here.

The problem is sometimes referred to as "the rectification of the circle", sometimes as "the quadrature of the circle". The former signifies the finding of *the length of the circumference* in terms of the diameter; the latter, the finding of *the area of the circle* in terms of the diameter (or

radius). The schoolboy's formula for the former is πd or $2\pi r$, and for the latter, πr^2, where r denotes the radius and d ($= 2r$) the diameter. The factor π is common to both formulæ, and for all practical purposes the two problems are identical. Each virtually resolves itself into finding *the value* of π, that is, *the ratio of the circumference to the diameter of a circle.* The Greek letter π (pronounced *pie*) is the initial letter of the word περιφέρεια (circumference, periphery), and it has been in use since the seventeenth century.

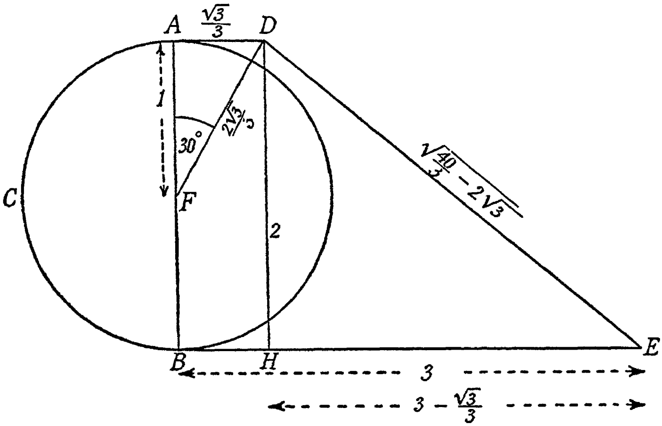

Fig. 16

Here are two well-known constructions with ruler and compasses.

1. By **Kochansky** (*Acta Eruditorum*, 1685) (fig. 16). Draw tangents AD and BE at the extremities of the diameter AB of the circle ABC, of which F is the centre.

Make $\angle$AFD $= 30°$, and make BE $= 3$AF.
Join DE.
DE $= \frac{1}{2}$ circumference of the circle.

For if AF $= 1$, it is easily proved that DE $= \sqrt{\frac{40}{3} - 2\sqrt{3}}$ $= 3{\cdot}141533\ldots$, a correct value of π to 4 places of decimals.

2. By **Jacob de Gelder** (*Grunert's Archiv.*, Vol. 7, 1849) (fig. 17).

AC and BD are perpendicular diameters of circle ABCD with centre E; EA (radius) = 1.

Make EF = $\frac{7}{8}$; join BF.
Make BG = $\frac{1}{2}$.
Draw GH perpendicular to BD; join HF.
Draw GK parallel to FH.

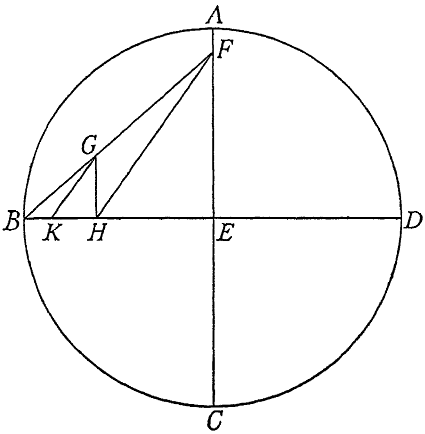

Fig. 17

Then, from similar triangles and from Pythagoras, $BK = \frac{4^2}{7^2 + 8^2} = \cdot 14159291\ldots$. This added to 3 (= 3 times the radius) gives the length of the value of π correct to 6 places of decimals, a remarkable degree of accuracy.

Both constructions (there are many others) are good enough for all *practical* purposes, but they do not really solve our problem. It is true that the solutions are so nearly correct that it would be quite impossible, with ruler and compasses, to show a deviation from values known to be far more correct, no matter how large and how carefully

drawn the geometrical figures. Mathematically, however, the solutions are demonstrably incorrect.

Many of the geometrical figures which we construct with ruler and compasses are acceptable to the mathematician because they really do correspond, in a rough sort of way, to the abstract figures which underlie his reasoning. We cannot, of course, draw "geometrical" lines, for such lines have no breadth, no material existence; we make marks on paper instead, and make shift with them. If we draw a circle, and step round the circumference with the unaltered compasses, we get round in exactly six steps, though each step we make measures, of course, not an arc but the straight chord across the arc; and the mathematician's abstract reasoning about it happens to correspond exactly to the material figure as drawn. But if we adopt the architect's common plan of inscribing a polygon in a circle, say a heptagon, the case is entirely different. The architect would divide a diameter into seven equal parts (a simple problem, see fig. 18), construct an equilateral triangle on the diameter, and from the vertex of the triangle draw lines through the points of division to cut the semicircle on the opposite side (fig. 18). The semicircle thus divided into seven parts (the second semicircle can be stepped round, and then the alternate points will give the seven points for the whole circle) will, in practice, be

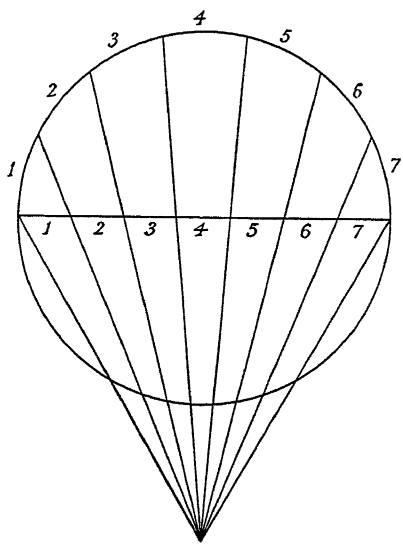

Fig 18

divided so accurately, if done by a skilful draughtsman, that it will be utterly impossible to demonstrate with ruler and compasses that the method is mathematically wrong. But the mathematician can show at once that the method gives only an approximation. It is just a draughtsman's useful dodge, hit upon by chance and not reasoned out, purely mechanical, unmathematical.

If the reader is to understand fully all that lies behind the old circle-squaring problem, it is essential for him to understand the difference between the mathematician's ideal problem and the ruler-and-compass problem. Whenever an ideal problem is solvable and can be demonstrated in Euclid's rigorous fashion, the corresponding constructive problem is always possible; but this practical solution can never be more than an approximation, limited by the imperfections both of the instruments used and of our eyes, though the approximation may be so close that no defect is perceptible. But the converse is certainly not necessarily true: when a practical problem is solvable by the use of instruments in such a way that the error is negligible or imperceptible, it does not at all follow that the corresponding ideal problem is also solvable. To an ideal problem which is known to be unsolvable, we may find an *approximate* solution, and we may make that approximation as close as we please by carrying the process far enough. The danger is in assuming that, because such a problem appears to be solvable by ruler-and-compass construction, it is therefore solvable mathematically, and that such a solution is not merely approximate but final and absolute. A mathematician never accepts a solution unless it can be rigorously demonstrated from first principles.

2. Irrational Numbers

Before outlining the history of the circle-squaring problem, we may usefully take the reader back to school for a short time. He will remember that, when a boy of about twelve, he had to evaluate π by actually measuring the diameter and the circumference of a given cylinder, perhaps the large cylinder borrowed from the art-room, perhaps a small and specially made cylinder from the physical laboratory. The measuring of the diameter was difficult enough and was probably inaccurate to the extent of $\frac{1}{50}$ of an inch; and that of the circumference was even more difficult, although the inevitable error was probably reduced to a minimum by winding a thread several times round the cylinder, unwinding, measuring the thread, and dividing. If the reader was able in this way to evaluate π correctly to one decimal place, he was probably complimented by his master. At the age of sixteen or seventeen, he may have repeated the experiment by a method demanding more skill, and he may have obtained a value correct to two decimal places. At the age of twelve he may have been told that the value to be remembered and used was $3\frac{1}{7}$; at the later age he may have been told to use the more accurate approximation 3·1416, or even 3·14159, his master emphasizing the fact that this value was, however, still only an approximation.

If the reader will write down the ordinary numbers from, say, 1 to 20, he will have before him 20 "rational" numbers. (A rational number is either a complete whole number, or a fraction consisting of two complete whole numbers, and it may therefore be either integral or fractional.) Between any two of them he may write other rational numbers; for example, between 2 and 3 he may write the mean, 2·5 ($2\frac{1}{2}$); between 2 and 2·5 he may again write the mean, 2·25 ($2\frac{1}{4}$); between 2 and 2·25 he may once more write the mean, 2·125 ($2\frac{1}{8}$); and so on indefinitely. Obviously, between *any*

two rational numbers we may write an infinite number of other rational numbers. We may write them down in different ways:

2	2	$\frac{2}{1}$	$\frac{2}{1}$	$\frac{2000}{1000}$
$2\frac{1}{8}$	$2 \cdot 125$	$\frac{17}{8}$	$\frac{2125}{1000}$	$\frac{2125}{1000}$
$2\frac{1}{4}$	$2 \cdot 25$	$\frac{9}{4}$	$\frac{225}{100}$	$\frac{2250}{1000}$
$2\frac{1}{2}$	$2 \cdot 5$	$\frac{5}{2}$	$\frac{25}{10}$	$\frac{2500}{1000}$
$2\frac{3}{4}$	$2 \cdot 75$	$\frac{11}{4}$	$\frac{275}{100}$	$\frac{2750}{1000}$
3	3	$\frac{3}{1}$	$\frac{3}{1}$	$\frac{3000}{1000}$

Other numbers, closely related to these, may also be interpolated, viz. recurring decimals: e.g. $2 \cdot \dot{3}$ ($= 2\frac{3333}{10000\ldots}$ $= 2\frac{1}{3}$ approximately).

Any *terminating* decimal, say $2 \cdot 537$, may be immediately expressed as a vulgar fraction and therefore as a rational number:

$$2 \cdot 537 = 2 + \frac{5}{10} + \frac{3}{100} + \frac{7}{1000} = \frac{2537}{1000}.$$

But what does a *recurring* decimal, say $\cdot 3333\ldots\ldots$ or $\cdot\dot{3}$ signify? It signifies an *unending series*:

$$\frac{3}{10} + \frac{3}{100} + \frac{3}{1000} + \frac{3}{10000} + \frac{3}{100000} + \cdots\cdots$$

and therefore a series *which it is impossible to sum.* But if any expressed number of terms be added together, the sum will approximate $\frac{1}{3}$, and the more terms we take, the closer will the approximation be to $\frac{1}{3}$, though $\frac{1}{3}$ will never actually be reached. We therefore speak of $\frac{1}{3}$ as the *limiting value* of the series, a value which, however, *can never actually be reached.* Similarly, the limiting value of

$$\cdot 4\dot{2} = \frac{42}{99} = \frac{14}{33}$$

and of $$\cdot 05\dot{6} = \frac{56-5}{900} = \frac{51}{900} = \frac{17}{300}.$$

These limiting values are clearly *rational* numbers, and evidently an unlimited number of such numbers may be interpolated between any two given rational numbers, say 2 and 3.

Thus between our two end-limits 2 and 3, we may interpolate two endless series, closely related, of rational numbers. But we may also interpolate a third endless series, viz. *irrational* numbers, i.e. numbers which can *not* be expressed in the form of vulgar fractions with numerator and denominator consisting of whole numbers; in other words, numbers which cannot be expressed as a *ratio* of whole numbers. They are expressed by *decimals which are endless and non-recurring*, and can therefore never express a value finally and completely, even as an approximating limiting value.

It is now definitely known that π is one of these irrational numbers.

Some irrational numbers may be correctly indicated by lines of definite length in geometrical figures. For instance, the diagonal of a square is $\sqrt{2}$ $(= 1\cdot41421.....)$ times the length of a side; also the perpendicular from the vertex to the opposite side of an equilateral triangle is $\frac{\sqrt{3}}{2} = \left(\frac{1\cdot732.....}{2}\right)$ times the length of that side; and $\sqrt{2}$ and $\sqrt{3}$ are both irrational numbers in the sense that they cannot be expressed as integral ratios. But the number π stands right outside all such geometrical simplicities. It is an irrational number of a very select class, defiant of all ordinary mathematical law.

3. The History of π

We may now turn to the history of this defiant symbol.

The history, which covers some 3000 years, falls definitely into three periods. The first period extends from the earliest times to about A.D. 1650. All this time the possibility of exact construction was never entirely lost sight of, and occasionally it was supposed to have been attained; it was essentially a

geometrical period, and much of the work done was based on the Greek method of exhaustions. In the earlier part of the period the work of approximation was much hampered by the backward condition of arithmetic, due to the fact that our system of numerical notation had not yet been invented. The second period lasted about a century; it was characterized by entirely new methods, due to the invention of the calculus. The third period covers the last two centuries, and during that time the nature of the number π has been critically investigated and is now known.

(α) The First Period

A papyrus which forms part of the Rhind collection of the British Museum was written by an Egyptian scribe named **Ahmes**, probably about 1600 B.C., and is itself mainly a copy of a treatise a thousand years older. In this papyrus the area of a circle is stated to be $(d - \frac{1}{9}d)^2$, d being the diameter. From this it is easy to deduce that the Egyptians calculated the value of π to be $2^8/3^4$ $(= 256/81) = 3\frac{13}{81} = 3{\cdot}16049.....)$ *How* they did it we do not know, though no doubt it was done empirically, probably by trial and error. It is correct to only the first decimal place and it is nearly 1 per cent too large.

Even so, the result was better than the assumption of the **Babylonians**, that $\pi = 3$. The Babylonians seem to have been led away, as the modern school-boy is led away the first time he uses a pair of compasses. He discovers that the radius steps exactly six times round the circumference, and therefore assumes that the length of the circumference is exactly three times that of the diameter, forgetting that the steps he makes do not measure sixths of the circumference but six short cuts (chords) across them. The same assumption ($\pi = 3$) was held for centuries, and there are two records of it in the Bible.

(1). 1 Kings vii. 23.

Authorized Version	*Revised Version*
And he made a molten sea, ten cubits from the one brim to the other, it was round all about, and his height was five cubits; and a line of thirty cubits did compass it round about.	And he made the molten sea of ten cubits from brim to brim, round in compass, and the height thereof was five cubits; and a line of thirty cubits compassed it round about.

(A *molten sea* was some kind of circular washing bowl)

(2). 2 Chronicles iv. 2, as before.

A similar statement occurs in the Jewish Talmud: "that which measures three lengths in circumference is one length across."

Many rule-of-thumb carpenters use the same value even at the present day.

The problem was first seriously attacked by the **Greeks,** who were the originators of geometry as an abstract science. Plutarch tells us that the philosopher and mathematician **Anaxagoras** (500–428 B.C.) "drew the quadrature of the circle" when in prison, but the method adopted is not recorded. About the year 420 B.C., **Hippias** of Elis invented a curve known as the τετραγωνίζουσα or *Quadratrix,* by means of which he was able to solve successfully one of the three famous problems of antiquity, viz. the trisection of the angle.* The device is easily understood.—Let OABC be a square and let OA and OC be radii of the quarter circle drawn from A to C. Let the radius OA rotate through the right angle to OC *in the same time* that it moves parallel to itself to CB. The point determined by the intersecting lines describes the quadratrix CQ. For instance, if OA rotates to OR in the same time as it moves parallel to itself to MN, the intersection of OR and MN gives a point (P) on the quadratrix (fig. 21).

* For a demonstration, see *The Endless Quest*, p. 48.

In the next century the mathematician **Dinostratus** showed that the quadratrix really gives a construction for π, for if the radius OA $= 1$, then OQ $= 2/\pi$.* But the real problem remains—the construction of the moving instrument itself. Hippias himself is said to have made one, and the construction is certainly not impossible. But ever since the time of Plato (420–347 B.C.), the strict mathematician has forbidden the use of any mechanical aid for geometrical constructions except ruler and compasses. Plato objected,

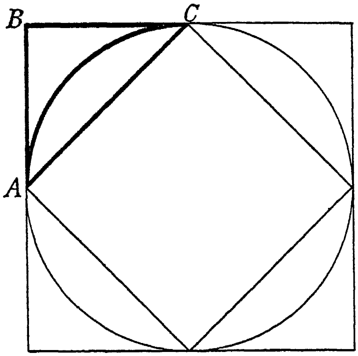

Fig 19

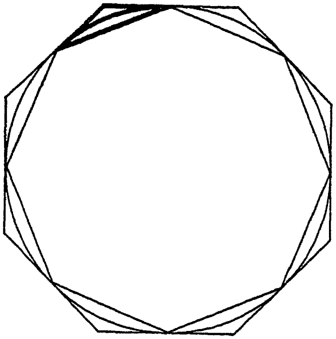

Fig 20

for instance, to the ingenious mechanical devices introduced by **Archytas** (*c.* 420 B.C.) for constructing curves. In any case, the quadratrix when drawn does not permit of an acceptable evaluation of π; really, it merely substitutes one difficulty for another.

An entirely different plan was worked out by **Antipho** (*c.* 420 B.C.) and **Bryso**, contemporaries of Plato's own famous teacher Socrates (469–399 B.C.). The main principle of the plan is easily demonstrated thus:

Fig. 19 shows a circle with inscribed and circumscribed squares, the sides of the latter being drawn as tangents at the angular points of the former. It is easily proved, if proof

* See Hobson, p. 14, or Young, p. 392, or Klein, pp 57–8.

is necessary, that the length of the arc AC is greater than the chord AC but less than the sum of the two tangents AB and CB. It therefore follows that the length of the circumference of the circle is *greater* than the perimeter of the inscribed square but *less* than the perimeter of the circumscribed square. The perimeters of the two squares are easily measured, and thus we can obtain a very rough approximation of the length of the circumference of the circle.

If instead of two squares we construct two polygons having a large number of sides, the same number in both cases, the perimeters will much more closely approximate to the length of the circumference of the circles. This is quite obvious from fig. 20, where the number of sides of the polygons in each case is only 8. If, then, the diameter of the circle is 1 in., if the calculated length of the perimeter of the outer polygon of x sides (where x is some large number) is 3·1417..... in., and if the calculated length of the perimeter of the inner polygon of x sides is 3·1413..... in., it follows that, since these two lengths agree to the third decimal place, the value 3·141 must indicate the length of the circumference to that degree of approximation. Obviously, by increasing the number of sides of the polygon, and so *exhausting* more and more the difference between their perimeters and the circumference of the circles, we obtain a value of π to any degree of approximation we please.

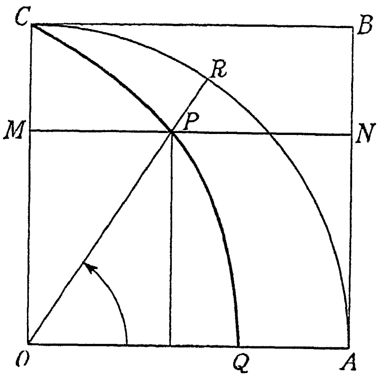

Fig 21

The plan was originated by **Antipho** who began with a square (fig. 19), then went on with an octagon, then with a 16-gon, and so on; but he used *inscribed* polygons only, arguing that the greater the number of sides in the polygon the closer would be the approximation to the circumference of

the circle. **Bryso** improved on this by using circumscribed polygons as well, thus foreshadowing the valuable device of later mathematicians of using upper and lower limits in a limiting process Bryso thought that the area of a circle could be found by taking the arithmetical mean of the areas of corresponding circumscribed and inscribed polygons. But here, of course, he was wrong.

A little later, another Greek mathematician, **Hippocrates** of Chios, attacked the problem. He was not satisfied with approximation methods, and he searched for plane figures bounded by curves which should be mathematically equal in area to plane figures bounded by straight lines, and which therefore would be convertible into a square of the same area.

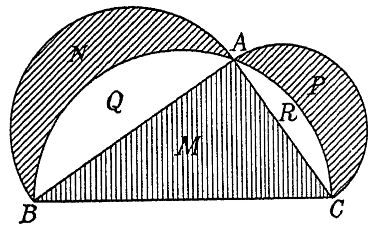

Fig 22

We show one of his figures (fig. 22). ABC is a right-angled triangle, with right angle at A, and semicircles are described on the three sides. The semicircle on BC, of course, passes through A. From Euclid I, 47 and XII, 2 it follows that

$$\text{semicircle on BC} = \text{semicircle on AB} + \text{semicircle on AC},$$

that is, $$(Q + M + R) = (N + Q) + (P + R);$$

$$\therefore \qquad M = N + P.$$

Thus the straight-lined triangle is equal in area to the sum of the areas of the two curved lunes.

Although in this and other ways (fig. 22 is only one of many) Hippocrates showed how the area of a curved figure could be expressed as the equivalent of the area of a rectilineal figure, he never succeeded in solving the far more important part of the main problem, viz. the conversion of a circle into a lune. His plan failed.

Euclid lived about a century later. He reduced geometry to a rigorously logical system, but he does not seem to have interested himself in the π problem.

The greatest of all Greek mathematicians, perhaps the greatest mathematician of history, with the possible exception of Newton, was **Archimedes** (287–212 B.C.). Even to this day he is admired for his masterly expositions and his logical rigour. His treatment of problems involving the determination of limits is unexceptionable; we never find him lost in the quicksands of infinitesimals, the fate of so many mathematicians after Newton and Leibniz had invented the calculus. The extent of his mathematical researches was vast indeed. His method of determining the value of π was, in principle, similar to that of Bryso, but he carried the scheme very much further, and the results he attained have always called forth admiration. His work is not likely to be appreciated fully unless we understand the extremely backward condition of Greek arithmetic. There was no system of notation as we know it now. The Greeks used the 24 letters of their alphabet, and three additional artificial signs (27 symbols in all), for the nine integers 1 to 9, for the multiples of ten, 10 to 90, and for the multiples of a hundred, 100 to 900. The 27 symbols were distinguished from ordinary letters by accents. The intermediate numbers were expressed by mere juxtaposition, and there was no symbol for zero! Let the reader try to work out a few sums in this notation, and gauge the difficulties for himself.

Archimedes first considered a regular hexagon, then a dodecagon, then a 24-gon, a 48-gon, and a 96-gon, inscribed within and circumscribed about a circle. The necessary calculations were of the most tedious character, especially as they involved the extractions of many square roots, but what methods Archimedes employed for this purpose we do not know: logarithms were not invented until nearly 2000 years afterwards.

Having calculated the perimeters of the inscribed and circumscribed 96-gons, he assumed that the circumference

of the circle lay between them. This led to the result

$$\frac{6336}{2017\frac{1}{4}} < \pi < \frac{14688}{4673\frac{1}{2}}.$$

He then showed that the first fraction is greater than $3\frac{10}{71}$ and the second less than $3\frac{1}{7}$, whence it followed with certainty that the value of π must lie between $3\frac{10}{70}$ and $3\frac{10}{71}$, that is, between $3{\cdot}142857\ldots..$ and $3{\cdot}140845\ldots..$ The mean of these values ($3{\cdot}141\ldots..$) is correct to 3 places of decimals, but we are not really justified in assuming that π is represented by the mean thus taken. The interesting thing about the result is this, that an enormous amount of skilled labour is required to obtain the value of π correct to only three decimal places.

The successors of Archimedes generally employed the approximation $3\frac{1}{7}$ for π, but the astronomer **Ptolemy** (A.D. 87–165) obtained an approximation even more correct than Archimedes, viz. $3{\cdot}14166\ldots..$

The **Romans** made few, if any, researches into the value of π. They were not interested, like the Greeks, in abstract mathematics. They were curiously like our twentieth-century selves—very practical, very just, but very illogical, altogether unlike modern Italians. It is a remarkable fact that the ancient Greeks, and the modern French, Germans and Italians have all been logical peoples and capable mathematicians; but the ancient Romans and the modern British have always been looked upon as illogical peoples and, save for a few, thoroughly incapable mathematicians. How quickly a friendly gathering of British people will melt away should any one of them touch on a mathematical subject! We can do many things, but we cannot reason logically. Listen to half a dozen average Englishmen talking politics: they will probably use some important political term in half a dozen different senses, and do it *unconsciously*, not realizing that these differences are probably the main causes of their differences of opinion.

The **Hindus** were another race of capable mathematicians. **Âryabhatta** (*c.* A.D. 500) knew the value $\frac{62832}{20000}$ for π, an approximation, 3·1416, even better than Ptolemy's, for it is nearly correct to 4 places of decimals (π really lies between 3·141592 and 3·141593). The most famous Hindu mathematician, **Brahmagapta** (b. A.D. 598) gave as the *exact* value of π, $\sqrt{10}$ (= 3·16.....); he certainly ought to have discovered that this was wrong. **Bhâskara** (b. A.D. 1114) working with 384-gons, obtained the value $\frac{3927}{1250}$, which agrees with that of **Âryabhatta** (3·1416), obtained 600 years before.

The **Chinese** were also competent mathematicians. Their best value of π was determined by their great astronomer, **Tsu Ch'ung-chih** (b. A.D. 430), who proved that it lay between 3·1415927 and 3·1415926. He was thus correct to 6 places of decimals.

The names of several circle-squaring mathematicians are mentioned during Renaissance times: **Leonardo Pisano, George Purbach, Cardinal Nicholas** of Cusa, **Simon Van Eyck**, and **Joseph Scaliger**, but none of them made any great advance.

But about the beginning of the seventeenth century, the Chinese value, 3·1415926..... was rediscovered by **Adriaen Anthonisz** (1527–1607) and was published by his son **Adriaen** (1571–1635), who assumed the name of **Metius.** The father had obtained the value by assuming that $\pi = 3\frac{15+17}{106+120}$ $(= 3\frac{16}{113} = \frac{355}{113})$, which is correct to the 6th decimal place, using the general method of Archimedes.

A Dutch soap-maker, **Jacob Marcelis** (1636–1714) claimed to have found a final solution, and he announced the value of π to be the rational numbers,

$$3\frac{1008449087377541679894282184894}{6997183637540819440035239271702}.$$

Needless to say it is incorrect, as may be seen by a glance at the first bit of the fraction. Jacob may have made good soap but his mathematics left something to be desired.

Archimedes' polygon method had, in some form or another been used by nearly all circle-squarers, and it occurred to the French mathematician **Vieta** (François Viète, 1540–1603) that π might be represented with greater mathematical exactness by means of a *series* of terms indefinitely extended. It was after a prolonged and careful examination of polygons inscribed in a circle, each polygon having twice the number of sides of its predecessor, that he hit upon, "divined", the following series:

$$\sqrt{\tfrac{1}{2}} \times \sqrt{(\tfrac{1}{2} + \tfrac{1}{2}\sqrt{\tfrac{1}{2}})} \times \sqrt{\{\tfrac{1}{2} + \tfrac{1}{2}\sqrt{(\tfrac{1}{2} + \tfrac{1}{2}\sqrt{\tfrac{1}{2}})}\}} \times \ldots \textit{ad inf.}$$

Vieta stated that this series gave the value of the ratio

$$\frac{\text{area of a square}}{\text{area of circumscribing circle}},$$

the degree of approximation depending on the number of terms taken. He began with a hexagon and proceeded to a polygon of $6 \cdot 2^{16}$ sides, and he showed that if the diameter of the circle be 100000, the circumference is

$$> 314159\tfrac{26535}{100\,000}, \text{ but } < 314159\tfrac{26537}{100.000}.$$

He thus obtained π correct to 9 places of decimals.—Vieta was the first to suggest an infinite series for calculating π. How he came to "hit upon" or "divine" this new method, we do not know. The intuition could have come to only a highly trained mathematician.

But Vieta was outdone by **Adrianus Romanus** (1561–1615), who obtained π correct to 15 places. To do this he had to undertake the forbidding task of finding the perimeter of a polygon of over a thousand million sides! *How* forbidding only a mathematician can appreciate.

In his turn, Adrian was completely outshone by **Ludolph van Ceulen** (1539–1610), who by an incredible amount of labour obtained a value correct to 35 decimal places. In Germany, π is still known as the *Ludolphian* number. By Ludolph's wish the value was engraved on his tombstone.

Although the Archimedean cyclo-polygonal method had now produced a degree of exactness which was far more than sufficient for every possible practical purpose that could ever arise, the problem had not yet been theoretically solved, and mathematically the great labour of Ludolph and his predecessors had relatively little value. The time was now approaching when the problem was to be attacked in an entirely different way.

Mainly owing to advances made in trigonometry, **Snell** (1580–1626), Professor of Mathematics at Leiden in Holland, showed how, without increasing the number of sides of the polygons, closer approximations of π might be determined. Using only hexagons, he obtained results as good as Archimedes had obtained 2000 years before with 96-gons. He verified Ludolph's results, using far simpler polygons, and probably not spending one-fiftieth part of the time that Ludolph had done.

The extreme limit of what can be done on the lines laid down by Archimedes was reached by another Dutchman, **Christiaan Huygens** (1629–1695). The π value determined by Archimedes Huygens was able to obtain from a triangle alone. Huygens was "the great simplifier of Archimedes' method, and he showed how to obtain three times as many decimal places for the π approximation as by the original method. He engaged in a lively controversy with the celebrated Scottish mathematician, **James Gregory** (1638–75), who attempted to prove that the squaring of the circle is impossible. Huygens himself was convinced of the impossibility, but he denied that Gregory had proved it. In point of fact the time was not yet ripe for such a proof; higher mathematics had still a long way to go before that was possible. The way was, however, being prepared, and during the seventeenth century three new powerful mathematical instruments were forged: (1) *Logarithms* by the Scottish mathematician, **John Napier** (1550–1617); (2) *Co-ordinate Geometry* by the French philosopher and mathematician, **René Descartes** (1596–1650); and (3) the *Calculus* by the English mathe-

matician **Isaac Newton** (1642–1727), and the German mathematician, **Leibniz** (1646–1716). With these three instruments available mathematics made great strides.

(β) The Second Period

The second period began in Newton's time and lasted about a century. The older geometrical methods gave way to algebraic, the new calculus having provided powerful analytical methods for determining the value of π in the form of convergent series, products, and continued fractions. New π calculators were soon at work, for in the new methods they saw vastly enhanced means of obtaining more decimal places, and therefore of a possible discovery of the real nature of π. It certainly did become possible to obtain a value to any desired degree of approximation.

The methods are beyond the full understanding of the reader who did no mathematics in his Sixth Form at school, and only an outline will therefore be given here. One or two preliminary hints as to the nature of underlying main principles may, however, be illuminating.

1. **Series.**—Consider an ordinary "infinite" series in geometrical progression, for example:

$$1,\ \tfrac{1}{2},\ \tfrac{1}{4},\ \tfrac{1}{8},\ \tfrac{1}{16},\ \tfrac{1}{32},\ \&c.$$

If we add the terms together, the sum of the first two is $1\frac{1}{2}$; of the first three, $1\frac{3}{4}$; of the first four, $1\frac{7}{8}$; of the first five, $1\frac{15}{16}$; of the first six, $1\frac{31}{32}$; of the first twenty, $1\frac{524287}{524288}$. Evidently the more terms we take, the nearer does the sum approach 2, but the sum can never actually reach 2 (cf. p. 105). The value 2 is an unreachable outside limit, and is called the *limiting* value of the sum of the series. If even a million terms were added, this limit would not be reached. *An infinite series can never be summed*: there is always an unbridgeable gap at the end. There are many types of infinite

series for which a limiting value may be found, but there are others which cannot be brought within such a scheme.

2. **An Infinite Series due to Archimedes.**—Archimedes devised a means of finding the area of a *parabola.* A parabola is, of course, an indefinitely extending curve, one of the well-known conic sections. Archimedes found the area QSP enclosed by any chord PQ (fig. 23).

Let M be the middle point of the chord, and draw MS parallel to the axis of the parabola; complete the triangle PSQ, and call the area of this triangle 1.

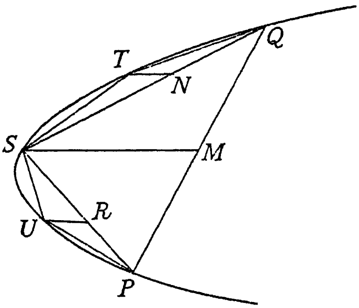

Fig 23

In the two small segments bounded by the chords SQ and SP, draw triangles STQ and SUP exactly as the first triangle was drawn, viz. by bisecting the chords at N and R and drawing parallels NT and RU to the axis. It is easily proved that each of the two triangles TSQ and USP is equal to $\frac{1}{8}$ of the triangle SPQ, and together are equal to $\frac{1}{4}$.

Again, in each of the four segments bounded by the chords QT, TS, SU, and UP, we may inscribe triangles exactly as before, and so we can proceed indefinitely *exhausting* to a greater and greater degree the area of the main segment QSP. The ratio $\frac{1}{4}$ holds good always. Thus the area of the parabolic segment QSP approximates ever more closely to the area determined by the sum of the following series:

$$1 + \tfrac{1}{4} + (\tfrac{1}{4})^2 + (\tfrac{1}{4})^3 + \dots$$

The sum approximates to the limit $\frac{4}{3}$; and it is now easy to establish formally that the area of the parabola cut off by the chord PQ actually is $\frac{4}{3}$ of the area of the triangle PQS.

3. **Inverse Notation.**—Most schoolboys now know something of trigonometry; for instance, they know that the

"tangent" of the angle α (fig. 24) is the ratio of the perpendicular PM to the base OM. A useful notation for showing the relation between the angle and its tangent is this: "$\tan^{-1}\alpha$". It reads, "the angle whose tangent is α". Observe that it means an *angle*. This useful notation is said to be "inverse".

4. **Circular Measure.**—For more advanced work, mathematicians find the "degree" (the angle formed by the $\frac{1}{360}$th part of a complete rotation) an inconvenient unit of angular measure. Instead, they use the unit called the *radian*, which

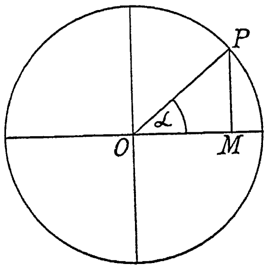

Fig 24

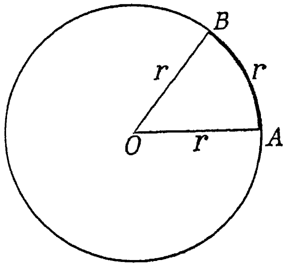

Fig. 25

is the angle subtended at the centre of any circle by an arc equal in length to the radius. It is roughly equivalent to about 57° (fig. 25). Since the arc equal to one radius subtends at the centre 1 radian, and since the semi-circumference is equal to π times the radius, the semi-circumference subtends at the centre π radians:

$$\therefore\ \pi \text{ radians} = 180^\circ,$$

$$\therefore\ 1 \text{ radian} = \frac{180^\circ}{\pi}.$$

It is useful to note that $90^\circ = \frac{\pi}{2}$ radians, and that $45^\circ = \frac{\pi}{4}$ radians. One advantage of this circular measure is that *a definite π relation is established between angles and their bounding*

arcs of circles, and thus an entirely new scheme for evaluating π becomes possible.

The reader ought now to be able to understand what follows.

Even before the invention of the calculus by Newton and Leibniz, **John Wallis** (1616–1703), who became Savilian Professor of Geometry at Oxford, had specially interested himself in infinite series, perhaps because of his early attachment to the works of Archimedes. In his well-known work *Arithmetica Infinitorum* he gave an expression for π as an infinite product:

$$\frac{\pi}{4} = \tfrac{2}{3} \times \tfrac{4}{3} \times \tfrac{4}{5} \times \tfrac{6}{5} \times \tfrac{6}{7} \times \tfrac{8}{7} \times \tfrac{8}{9} \times \ldots.$$

and he showed that the result always comes out too small if we stop at a proper fraction, but too large if we stop at an improper fraction. The expression has the advantage over that of Vieta in that it does not involve the extraction of roots; the operations are all rational.

Lord Brouncker (1620–84), the first President of the Royal Society, provided Wallis with an alternative expression, though without proof. It took the form of a continued fraction:

$$\frac{4}{\pi} = 1 + \cfrac{1}{2 + \cfrac{9}{2 + \cfrac{25}{2 + \cfrac{49}{2 + \cfrac{81}{2 + \ldots}}}}}$$

The expression from which most of the practical methods of calculating π have been obtained is the series discovered by **Gregory:**

$$\tan^{-1}x = x - \frac{x^3}{3} + \frac{x^5}{5} - \frac{x^7}{7} + \ldots.$$

If we write $x = 1$, we have

$$\frac{\pi}{4} = 1 - \tfrac{1}{3} + \tfrac{1}{5} - \tfrac{1}{7} + \dots.$$

This series bears the name of **Leibniz** who discovered it independently, but it converges very slowly, and a large number of terms has to be taken into account in order to obtain a correct value of π to even a few decimal places. If instead of writing $x = 1$ in Gregory's series, we write $x = \sqrt{\tfrac{1}{3}}$, the series is much more manageable.

Abraham Sharp, acting on hints from Halley the astronomer, calculated π from Gregory's series up to 72 decimal places.

Both **Newton** and **Euler** devised more quickly convergent series, but better known than theirs is the series devised by **Machin** (1680–1752), Professor of Astronomy in London.

$$\frac{\pi}{4} = 4\left(\frac{1}{5} - \frac{1}{3\cdot5^3} + \frac{1}{5\cdot5^5} - \frac{1}{7\cdot5^7} + \dots\right) - \left(\frac{1}{239} - \frac{1}{3\cdot239^3} + \frac{1}{5\cdot239^5} - \frac{1}{7\cdot239^7} + \dots\right).$$

From this series Machin himself evaluated π to 100 decimal places. The series follows from the relation

$$\frac{\pi}{4} = 4\tan^{-1}\tfrac{1}{5} - \tan^{-1}\tfrac{1}{239}.$$

The expression is more convenient than might be supposed, for in the first part of the series the fractions are readily simplified, and the second part is very rapidly convergent.

Various other formulæ were also used, and, by degrees, closer and closer approximations were found. **De Lagny** of Paris (1660–1734) obtained 127 decimal places; **Georg Vega** (1754–1802), an Austrian, 140; **Zacharias Dase** (1824–61) of Hamburg, 200; **Richter,** 500; **W. Shanks** (in 1873), working with Machin's formula, 707.

If the reader is interested in arithmetic, let him work out for himself, say, Machin's formula to 20 or 30 terms. Only then will he be able to gauge the stupendous task that these men set themselves. Think of it: 707 decimal places! and even then the secret not discovered; no sign of recurring decimals, no sign of any sort of mathematical law!

The practical value of 700 places of decimals, or even of 100, is, of course, *nil.* If the whole visible universe (see the previous chapter) was closely packed with the smallest particles that can be conceived, and if the particles could be counted, the number which would express them, would not, by a very long way, consist of 100 figures. All the π calculators must have known that their work could have had no practical value, and yet some of them must have spent literally many years in arithmetic of the most laborious character. They all hoped to discover the secret of the *nature* of π. Had they done so, they would doubtless have reaped their reward. Think of Shanks's bitter disappointment when at the 707th decimal place he finally abandoned his task! It is now definitely known that the π problem is unsolvable, and that any further work upon it must be utterly fruitless. Mathematicians had long been convinced of this, but until 1882 there had been no final demonstration.

(γ) The Third Period

The third period lasted from the middle of the eighteenth century until nearly the end of the nineteenth. Mathematicians now had at their disposal powerful means of solving different types of problems, and they turned their attention to a critical investigation of the true *nature* of the number π. Could it possibly be a *rational* number, a vulgar fraction with a definite numerator and a definite denominator, even if these were forbiddingly large—in other words, a terminating or circulating decimal? or was it an *irrational* number, and, if so, what *kind* of an irrational number? The new method was no

longer to be based on an examination of an increasingly large number of decimal places, it was a method of *analysis*. The method taxed the resources of the ablest mathematicians, and here it is possible to give only some brief indication of its nature. Readers who did a fair amount of mathematics at school may be able to follow the formal proofs to which reference may be made later; others must be content with the following outline.

But first a few words about algebraic equations and geometrical constructions.

(1) Co-ordinate geometry was invented by Descartes about 1635; this was really a system by which geometrical problems could be solved algebraically. A simple framework of two lines at right angles to each other enables the mathematician to fix in position his geometrical lines and curves, to take measurements, and to express these algebraically. He manipulates the formulæ thus obtained in such a way as to give him the position of new points through which he can draw new lines; he is thus able to solve his geometrical problem. To illustrate simply:

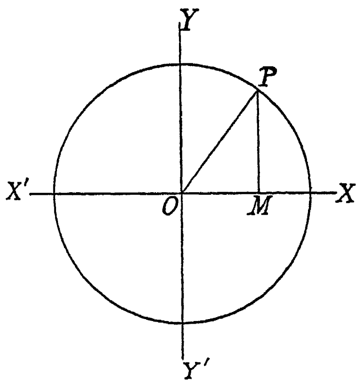

Fig 26

Let the co-ordinate axes (the framework) intersect at O. If O be the centre of a circle (fig. 26), any point P on the circumference is determined by its distance PM from OX and its distance OM from O. Since OP is the radius,

$$OP^2 = OM^2 + PM^2,$$

or,

$$r^2 = x^2 + y^2,$$

where x and y represent the distances OM and PM. This

equation, $x^2 + y^2 = r^2$, the mathematician now uses to solve any given geometrical problem concerning the circle.

Similarly with the parabola (fig. 27). The distance RS of any point R on the curve to OX is always equal to the square of the distance OS, and the mathematician therefore uses the equation

$$y = x^2$$

for solving geometrical problems concerning the parabola.

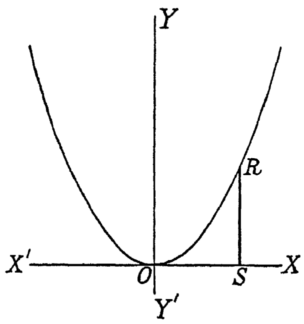

Fig 27

All this is familiar enough to Middle Form schoolboys, and the reader may have no fear that the solutions of geometrical problems which are solved algebraically are in any way impaired in rigour.

Equations may, of course, be of any "degree". Here are a few examples:

Simple equation,	$x - 1 = 0.$
Quadratic equation,	$x^2 - 3x + 2 = 0.$
Cubic equation,	$3x^3 - 10x^2 + 9x - 2 = 0.$
Biquadratic equation,	$12x^4 - 43x^3 + 46x^2 - 17x + 2 = 0.$

And so on.

The roots of the above biquadratic are 1, 2, $\frac{1}{3}$, and $\frac{1}{4}$, that is, these 4 numbers (in this case all rational) represent the 4 values of x in the equation. This may be checked by substitution; for instance, we may substitute the value 2; then,

$$\begin{aligned} & 12 \cdot 2^4 - 43 \cdot 2^3 + 46 \cdot 2^2 - 17 \cdot 2 + 2 \\ = & \ 192 - 344 + 184 - 34 + 2 \\ = & \ 378 - 378 \\ = & \ 0, \text{ as expected.} \end{aligned}$$

All equations can be represented by "curves" (they may be straight lines) on the framework of co-ordinate axes

X′OX, Y′OY. The roots represent points which indicate definite distances from O on the axis OX, for example, above, 1, 2, $\frac{1}{3}$, and $\frac{1}{4}$ units away. An equation which can be solved always gives us "roots" the numerical values of which thus fix points in the X′OX axis.

The multiplying numbers 12, 43, 46, and 17 in the above equation are—disregarding signs—the *coefficients* of x^4, x^3, x^2, and x, respectively.

Schoolboys know a great deal about simple and quadratic equations, and a certain amount about cubics and biquadratics. But quintics and equations of higher orders are the concern of highly trained mathematicians.

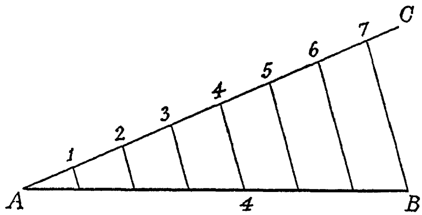

Fig 28

(2) Simple geometrical constructions with ruler and compasses usually form a child's introduction to geometry: the bisection of a line, the erection of a perpendicular, the construction of a square, the division of a straight line into a number of equal parts—these are typical problems for little boys. The reader should notice that the construction for cutting off a fraction of a line is quite simple. For instance, we may cut off $\frac{4}{7}$ of the line AB.—Draw AC at any angle to AB, mark off on AC seven equal divisions (1 to 7) of any length, join 7B, and then draw parallels to 7B; since these parallels cut the sides A7 and AB proportionately, it follows that A4 is $\frac{4}{7}$ of AB, as required (fig. 28).

The construction for determining the square roots of numbers, whole or fractional, is equally simple.—Take a right-angled triangle with two sides of unit length about

the right angle; by the theorem of Pythagoras the length of the hypotenuse is $\sqrt{1^2 + 1^2} = \sqrt{2}$. Now make a second right-angled triangle with sides about the right angle 1 and $\sqrt{2}$; the hypotenuse is $\sqrt{(\sqrt{2})^2 + 1^2} = \sqrt{3}$. Again, a third triangle, with sides about the right angle 1 and $\sqrt{3}$; the hypotenuse is $\sqrt{(\sqrt{3})^2 + 1^2} = \sqrt{4} = 2$. And so on (fig. 29). In this way we can construct a right-angled triangle to show the square root of any whole number whatsoever. But we need not always proceed in successive steps from unity. For instance, $\sqrt{122} = \sqrt{121 + 1} = \sqrt{11^2 + 1^2}$; hence, if we construct a right-angled triangle with sides about the right angle of 11 and 1, the length of the hypotenuse is $\sqrt{11^2 + 1^2} = \sqrt{122}$.

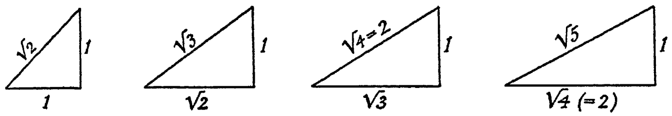

Fig 29

The construction for determining the square root of any vulgar fraction is just as simple, e.g. the square root of 564/59:

$$\sqrt{\frac{564}{59}} = \sqrt{\frac{564 \times 59}{59 \times 59}} = \frac{\sqrt{33276}}{59}.$$

Thus, we construct a right-angled triangle, as before, with an hypotenuse $\sqrt{33276}$, and then take $\frac{1}{59}$ of that hypotenuse, according to the construction in fig. 28.

Of course, in practice, such constructions would very rarely be carried out, but the important thing to notice is that such constructions are *possible*. Obviously irrational numbers of the kind above considered can be determined by ruler and compasses, the only instruments that Euclid would allow. (One of the most difficult of ruler-and-compass constructions is that of a 17-sided polygon, a construction which,

though now well known to mathematicians, is only of recent discovery.)

There is another remarkable number, closely associated with π mathematically, known as e. It is a sort of key number to logarithms, and its approximate value is expressed thus:

$$e = 1 + \frac{1}{1} + \frac{1}{1.2} + \frac{1}{1.2.3} + \dots$$
$$= 2{\cdot}71828 18\dots$$

Like π, it seems utterly intractable, and yet, like π, it is one of the very corner-stones of mathematics.

The first e and π discovery of fundamental importance was made by **J. H. Lambert** (1728–77), the German mathematician, who proved that both e and π are *irrational* numbers. The French mathematician, **A. M. Legendre** (1752–1833) supplied more rigorous proofs, and he also proved that π^2 is irrational. Thus it was proved that neither π nor π^2 can be exactly represented by a fraction the numerator and denominator of which are whole numbers, no matter how great the numbers may be.

Two interesting results follow from Lambert's proof that π is irrational.

(i) If π were evaluated to even a million places (which is quite possible) we should be virtually no nearer a final solution than we are now. We can express π as a number lying *between* two rational numbers, say A and B, and we can make the *difference* between A and B as small as we please. If, then, we evaluated π to a million places, the difference between this value and the imaginary " true " value would be inconceivably small and would get less and less as we increased the number of decimal places still further. But the difference would never actually vanish because no " true " value could ever be reached.

(ii) Lambert disposed finally of any possibility of π being equal to any *rational* number (like $3\frac{1}{8}$ or $3\frac{1}{7}$), but he left the question still open whether π might not be found by a

geometrical construction with ruler and compasses. Suppose, for example, that π turned out to be equal to something like the *irrational* number referred to on p. 126, viz. $\sqrt{564/59}$. This number is, of course, a root of the equation $59x^2 - 564 = 0$, and is easily determined with ruler and compasses as we have shown. Such an equation is obviously an equation with integral coefficients.

We now know that a solution of the π problem by means of such an equation is impossible, but this was not shown by Lambert.

A little later on the discovery was made that there is a fundamental distinction between (i) *Algebraic* and (ii) *Transcendental* numbers. Algebraic numbers are those which *can* be the roots of an algebraic equation with rational coefficients; transcendental numbers are those which *cannot* be the roots of an algebraic equation with rational coefficients. The question then naturally arose, to which of these two categories does the number π belong?

The first noteworthy step in the direction of a decision was made in 1840 by **Liouville** (1809–82) when he showed that e cannot be the root of a *quadratic* equation with rational coefficients (that is, if a, b, c are rational, the equation $ae^2 + be + c = 0$ is impossible). This was the first successful attempt towards verifying what Legendre had stated to be probable—that π cannot be classed among algebraic numbers. The question that still remained to be settled was this: did there exist *any* sort of an equation, perhaps of a very high degree, in which all the coefficients are whole numbers, having π for a root, so that it would check if its unknown quantity were made equal to π? or was π really transcendental?

In 1873 the French mathematician **Ch. Hermite**, succeeded in showing that the number e is transcendental, and finally, in 1882, the German mathematician **Lindemann** showed that π is transcendental. The proofs * are complicated

* The best are given by Hobson, *Squaring the Circle*, pp. 42–57. Simpler forms are given in *Monographs on Modern Mathematics*, Article IX, by J W A. Young; in Schubert's *Mathematical Essays*; and in Klein's *Famous Problems in Elementary Geometry*, ed. Beman Smith

and difficult, but all mathematicians agree that the fact of π being transcendental leads to the inescapable conclusion that π does not admit of any sort of geometrical construction or of any sort of algebraic evaluation. Although the conclusion seems to be negative in character, the mathematical reasons on which the negative conclusion rests are incontrovertible. It seems an astonishing thing that there should be no simple relation between the diameter and the circumference of a circle, but π seems to be a number standing defiantly outside all mathematical law. It is a simple enough matter to evaluate it to any degree of approximation whatever, but we are quite certain that the decimal places thus obtained will never recur and will never come to an end. It is agreed that Lindemann finally settled the question once for all.

It is a remarkable fact that the 3000 years of wrangling about π concerned only one of its properties—the ratio of the circumference to the diameter of a circle. Of far greater importance is its significance in higher mathematical analysis. The usual definition of π is very far from connoting all its properties.

4. Two Obstinate Circle-Squarers

Of the multitude of people who became obsessed with the belief that they had finally solved the famous problem, we may mention two, both Englishmen.

The first was a well-to-do commercial man of Liverpool, one **James Smith.** His ample means enabled him to publish books and pamphlets and to distribute them lavishly. Here are a few of them:

1. *The Problem of Squaring the Circle Solved.* By James Smith, London, 1859.
2. *On the relations of a Square inscribed in a Circle.* Read at the British Association, Sept. 1859. By James Smith.
3. *The Quadrature of the Circle.* Correspondence between

an eminent mathematician (Professor de Morgan) and James Smith, Esq.

4. *A nut to crack for the readers of Professor de Morgan's "Budget of Paradoxes"*. By James Smith, Esq., 1863.

5. *The British Association in Jeopardy, and Dr. Whewell, the Master of Trinity, in the stocks without hope of escape.* James Smith, 1865.

6. *The British Association in Jeopardy, and Professor de Morgan in the Pillory without hope of escape.* James Smith, London, 1866.

James Smith, who knew less about mathematics than a modern thirteen-year-old schoolboy, seems to have heard that a French well-sinker named Lacomme, who had been commissioned to construct a circular reservoir, was puzzled about the amount of stone necessary because he was ignorant of the value of π. Eventually Lacomme, by mechanical measurements, calculated π to be exactly $3\frac{1}{8}$, and Smith, hearing of this, promptly adopted it, and nothing could shake his conviction afterwards that $3\frac{1}{8}$ was the true value of π. Apparently the very neatness of the figures attracted him:

$$3\tfrac{1}{8} = \frac{25}{8} = \frac{5^2}{2^3}.$$

He believed that nature always worked in this trim fashion and never finished off her tasks with trails of uncertainties.

So obsessed did Smith become with his wonderful discovery that he made himself a public nuisance. The British Association let him talk and write, but otherwise they ignored him. Sir W. R. Hamilton, the eminent mathematician, sent him a proof that he was wrong, a proof that would have immediately convinced any intelligent schoolboy, but not so Smith. The Master of Trinity, Whewell, another eminent mathematician, also sent him a simply reasoned but conclusive proof that he was wrong, but Smith scoffed at Whewell, as he had done at Hamilton. Then Smith tried to convert a third eminent mathematician, De Morgan, and this time he was lashed and lashed again.

It was Smith's custom, when he discovered some conclusion which agreed with his own π assumption, to regard that agreement as proof of the assumption. One "piece of information" which he sent to De Morgan, "which would settle him if he were honest", was the following "remarkable general principle":

By assuming π to be $3\frac{1}{8}$, and by working out several particular examples, he found that the mean proportional between $\frac{1}{5}$ of the area and $\frac{1}{5}$ of 8 is the radius, i.e.

$$\text{if } \pi = \frac{5^2}{8}, \text{ then } r = \sqrt{\frac{\pi r^2}{5} \cdot \frac{8}{5}}.$$

Naturally de Morgan promptly pointed out that the same result followed from any other numbers than 5 and 8. For instance, if a and b are any two numbers whatever, we need only assume that

$$\pi = \frac{a^2}{b} \text{ to get } r = \sqrt{\frac{\pi r^2}{a} \cdot \frac{b}{a}}.$$

Smith was so utterly incapable of following up the simplest mathematical argument, or of understanding the nature of mathematical proof, that he hopelessly gave himself away again when he replied to De Morgan:

"I think you will not dare to dispute my right to this hypothesis ($\pi = 3\frac{1}{8}$) when I can prove by means of it that every other value of π will lead to the grossest absurdities; unless indeed you are prepared to dispute the right of Euclid to adopt a false line hypothetically for the purpose of a *reductio ad absurdum* demonstration in pure geometry."

To which De Morgan replied, "Euclid assumes what he wants to *disprove*, and shows that his *assumption* leads to absurdity. Mr. Smith assumes what he wants to *prove*, and shows that *his* assumption makes *other propositions* lead to absurdity."

And in his *Budget of Paradoxes*, De Morgan publishes his opinion of Smith in these terms:

"He is beyond doubt the ablest head at unreasoning, and the greatest hand at writing it, of all who have tried in our day to attach their names to an error. Common circle-squarers sink into puny orthodoxy by his side." He is "the supreme Pontiff of circle-squarers, the vice-gerent of St. Vitus upon earth, the mamamouchi of burlesque on inference."

It may seem surprising that such eminent men as Hamilton, Whewell, and De Morgan should have taken any notice of a man like Smith. But it has to be remembered that Smith was a rich man and that he flooded the country with pamphlets tending to hold up mathematicians to ridicule. Most Englishmen—I am not quite sure about Scotsmen—are so shy of mathematics, that unless Smith's ignorance had been authoritatively exposed, public sympathy would probably have been on his side. Smith's arguments were puerile, and they were fallacious from end to end; nevertheless very few ordinary people could weigh up their merits. As a race we are curiously indifferent to getting down to bed-rock facts. Luckily there are a *few* serious thinkers amongst us.

Our second famous circle-squarer lived two centuries earlier than Smith and was altogether a different type of man. This was **Thomas Hobbes** (1588–1679), the son of a rather ill-tempered, unscholarly Wiltshire parson. He rose to great eminence as a philosopher: in fact, he was the principal English philosopher during the period between Bacon and Locke. He numbered among his friends such illustrious men as Ben Jonson, Bacon, Lord Herbert of Cherbury, Harvey, and Descartes. At Oxford he distinguished himself as a classical scholar and was recognized as an authority on Thucydides. But he hated the futility of the scholastic word-quibbling which still survived there, and he interested himself mainly in history, politics, and certain phases of philosophy. He must be classed with philosophers like Kant and Locke, rather than with men of science like Galileo and Newton. It is true that, as the years went on, mathematics and science

attracted him, but his early training did not fit him for so late a serious study of these subjects, and all his life his knowledge of them remained extremely superficial. Actual experimental work he could not appreciate; indeed, he was rather scornful of it, and he would have nothing to do with Baconian induction; in fact his methods were, at bottom, critically deductive. Of cold scientific impartiality he possessed very little, but he was particularly clever in concealing the shallowness of his own reasoning by enlarging upon the stupidity and wickedness of the other side.

From the time he left Oxford until early middle age Hobbes lived on the continent, and when he returned to England he failed to discover that, during his absence, things had made great strides forward, especially at his old University. This failure was the cause of endless trouble to him in after years.

Hobbes' chief work, still regarded by philosophers as a classic, was the *Leviathan*, in which, amongst other things, he laid great stress upon the need of a reform of the universities. During his own youthful years at Oxford, he had learnt that universities were originally founded for the main purpose of bringing scholastic ingenuity to the support of Papal domination over the civil State; the old monasteries had been useful Papal forts, but the universities of Oxford and Cambridge had, in his student days, become veritable Papal fortresses where Scholasticism was still strongly entrenched and where the training of youth was largely given up to exercises in speculative subtlety. Hobbes demanded with great vehemence that the State must take control of the Universities and that drastic changes should be made in university studies; above all things the teaching of science must be introduced. He expressed himself in terms both scathing and bitter.

Needless to say, Oxford took careful note not only of these revolutionary suggestions and sweeping criticisms, but also of Hobbes' very obvious personal aspirations.

The contrast between the Oxford of 1603 when Hobbes was there, and the Oxford of 1651 when he fulminated against

it, was great indeed. Speculative subtleties doubtless survived (they survive even now: how else are our lawyers, priests, and politicians made?), but all sorts of far-reaching changes had been effected. Science especially was represented by men each in his own line a leader. In 1619, **Sir H. Savile** had founded professorships of astronomy and geometry, and these were now held by **Seth Ward** and **John Wallis,** respectively. With them worked **John Wilkins**, Warden of Wadham, afterwards first secretary to the Royal Society, and all three were not only men of great intellectual ability but they were imbued with the experimental spirit of Bacon. That three such men would tolerate being held up to public obloquy by one who, purposely or ignorantly, spoke of an Oxford that was certainly not theirs, and whose knowledge of science and mathematics was merely that of a child, was hardly to be expected.

Oxford, alternately with London, was the headquarters of the remarkable group of men who founded the Royal Society just after the Restoration. **Robert Boyle** and **Christopher Wren,** both very much younger than Hobbes, were amongst them.

The five men we have named—Ward, Wallis, Wilkins, Boyle, and Wren—were, with Newton a little later, in the very front rank of mathematicians and men of science, yet Hobbes, with no sort of claim to be included amongst them, was wounded to the quick because he was not invited to become their leader. His knowledge of mathematics was superficial in the extreme; his knowledge of physical science was virtually *nil.* He treated with disdain those who sought evidence by experimental research. It is a remarkable fact that the one thing which the Oxford of his youth had really taught him and taught him well, viz. that all knowledge is obtained by deductive reasoning from premisses assumed to be true, he now quite failed to unlearn. The very thing he was so vehemently denouncing in the Oxford he now despised held him as in a vice. And he was utterly unconscious of it.

Hobbes was over 40 when he first saw a copy of Euclid.

He was in a friend's library, and came across a copy by chance, the volume lying open at the 47th proposition (the theorem of Pythagoras) of Book I. Reading the proposition he exclaimed, "By God, this is impossible!" He read the demonstration, then the previous propositions which supported it, then the still earlier propositions which supported these, and so worked his way back to the axioms, until he was "demonstratively convinced" of the truth of the Pythagoras theorem. "This made him in love with geometry." The mode of the reasoning and the subject itself attracted him, and henceforth mathematics became a sort of Jack o' Lantern to him.

But now Hobbes made a profound mistake. He assumed that, by merely reading the solutions of mathematical problems, as in Euclid, he himself would become a mathematician. He failed utterly to realize that a mathematician can become master of his subject only by attacking problems and solving them; that above all things a mathematician's work is *analytical*—the systematic analysis of the conditions of any given problem is the first essential; and that only by a great deal of this kind of work can mathematical skill be acquired. The subsequent synthesis, the mere setting out of the solution of a problem in deductive dress, is the mathematician's final task and is mere child's play. Poor Hobbes never understood this. He was too old to settle down to the hard grind of a new subject so alien to his nature, and, having no real knowledge of mathematics he readily became the sport of mathematicians.

Hobbes' attack on the Universities in his *Leviathan* was bound to call forth a reply. Wilkins of Wadham was the first to take up the challenge, and in a letter to Ward charged Hobbes with arrogance and hinted at plagiarism. Ward repeated the charge of plagiarism, mocked at the pretensions of *Leviathan*, and defended the Universities. He admitted that during Hobbes' youth the Universities might not have freed themselves completely from mediævalism, but Hobbes would very soon find that they were now fully able to see through

his pretentious mathematical discoveries, should these ever be published.—The allusion was to " the wonderful circle-squaring solutions " of which Hobbes had been boasting.

These discoveries saw the light in Hobbes' new book, *De Corpore*, and in one chapter he was unwise enough to claim that he had solved the problem which had baffled all previous geometers from Archimedes onwards. Few men have ever made a more unlucky boast. His vaunted achievement really amounted to no more than this: first, a quadrature was put forward but admitted to be incorrect, because from a faulty hypothesis; a second, merely approximate; a third, given first as exact but at last as only " problematically said "; and that was all. With childlike simplicity he added that he should have held the hypothesis in the first attempt as true, had not the insults of malevolent men forced him to look into it more closely; the third attempt he had seen to be open to objection only after it was printed.—He had, indeed, delivered himself into the hands of his enemies.

Ward and Wallis promptly agreed to expose him. Ward was to confine himself to the philosophical sections of *De Corpore*, and Wallis to the mathematical. Wallis managed to get hold of an early " unbound copy " (apparently former corrected proof-sheets) of the book, which showed a grotesque succession of vain attempts to solve the problem, and Wallis was easily able to follow the tracks of the whole of Hobbes' circle-squaring pilgrimage from the time of Ward's provocation—his pilgrimage from exultation to doubt, from doubt to confessed impotence.

Hobbes was the easy sport of Wallis, and Wallis was ruthless. In an *Elenchus Geometriæ Hobbianæ*, Wallis not only showed how utterly incapable Hobbes was even of appreciating the conditions of mathematical proof, but he showed how Hobbes had again and again printed loose assumptions as strict truths, and rough and contradictory approximations as exact solutions of an impossible problem. Wallis never changed his coarse mockery except to fall into a still more irritating vein of solemn sermonizing.

Little wonder that Hobbes was stirred to a mood of fierce resentment, though he was too incompetent even to know that he had been refuted. With a courage worthy of a better cause, he actually defended his own errors and gave fresh proofs of incapacity by attacking Wallis's own masterly mathematical discoveries, in *Six Lessons for Oxford Professors*. It should be borne in mind that Wallis was a brilliant mathematician, and his *Arithmetica Infinitorum*, published in 1655, was a very great step towards the development of the calculus by Newton and Leibniz. The *Six Lessons* betrayed an amazing incomprehension of Wallis's discoveries and ingenious methods in the *Arithmetica*. The worst that Hobbes could say was that much of Wallis's work was " so covered over with the scab of symbols " that he had no patience to examine it.

Wallis, in his reply, treated Hobbes like a naughty little schoolboy. *Due corrections for Mr. Hobbes, or School Discipline for not saying his Lessons right.* Wallis swished and swished again. Once more he exposed Hobbes' incredible inconsistencies.

Both men were, of course, masters of verbal fence, and when Hobbes dealt with a subject he really understood he was a formidable antagonist. But for Hobbes to pose as a mathematician when fighting a brilliant mathematician like Wallis was a piece of unbelievable folly. What chance has a noisy little terrier against a boarhound? Unfortunately, however, language on both sides became more and more personal, abusive, and filled with innuendo.

In 1657, Hobbes hoped to bring the unseemly wrangle to an end, but instead of being conciliatory he became more provocative than ever. In his *Six Lessons* he had argued that a mathematical point must have quantity, and he had interpreted the Greek word στίγμα, used for a point, to mean a visible mark made with a hot iron; and Wallis had written in reply a rather insulting paragraph, charging Hobbes with having made a gross and ignorant confusion of στιγμή and στίγμα. Hobbes' new book was therefore given the title Στιγμαὶ 'Αγεωμετρίας, 'Αγροικίας, 'Αντιπολιτείας, Ἀμαθείας,

or *Marks of the absurd Geometry, Rural Language, Scottish Church Politics, and Barbarisms of John Wallis.* In this Hobbes attacked the *Arithmetica Infinitorum*, the attacks being so puerile as to suggest that Hobbes was hardly familiar with his tables. He also made various insinuations of a personal character, but Wallis was once more easily able to return a crushing reply.

When the Royal Society was founded in 1662, Hobbes was naturally not invited to join a body of which his antagonists were the leading members. He was furious, and he made a violent attack on the experimental researches of Boyle. "If people who tried such a farrago of experiments were to be called philosophers, the title might be bestowed upon apothecaries and gardeners and the like." He roundly told the Royal Society that they would learn nothing until they adopted his principles. It was Wallis who replied in the *Hobbius Heauton Timoroumenos*, a scathing satire in which Hobbes was simply torn to shreds. The satire was by far the greatest of Wallis's great exposures of the incoherence and futility of Hobbes' attempts at circle-squaring.

The battle was not yet over. In 1666 Hobbes, who was then 78, brought out a treatise, *De Principiis et Ratiocinatione Geometrarum*, in which he admitted that all geometers were against him but in which he hoped to lower their pride. Then came another circle-squaring solution, as well as solutions to other famous ancient mathematical problems. They were all stingingly refuted in a pamphlet from Wallis. Hobbes issued still other volumes in 1674 and 1678 (he was now 90), and almost at the end of his life the old man's desperate purpose was shown in yet one more solution of the squaring of the circle. He had maintained a fight for well over a quarter of a century and had lost every battle, every time being driven off the field ignominiously.

The world was inclined to regard Hobbes as a charlatan. Scientists, mathematicians, and many philosophers ostracized him. A man who could make such "a howling mess" of squaring the circle was presumably a paradox-monger in

philosophy. His failure was admitted by everyone but himself.

It was an unlucky day for Hobbes when he came across that open Euclid in a friend's library. A highly gifted man in many ways, he scarcely understood the *a*, *b*, *c* of mathematics, and though fighting hard for 30 years he never really understood what the fight was about. He kept his poor little tattered flag flying to the last.

Poor Hobbes! From middle age onward he was obsessed with the idea that he was a mathematician, and he died with the conviction that he had squared the circle.

Hobbes undoubtedly had a first-class brain. How then is his astonishing stupidity in mathematics to be explained? Cerebral lesions are common enough, as every psycho-therapist knows. Could Hobbes' stupidity have been due to some obscure and unknown cerebral trouble? Who can say? Or was it just an average Englishman's constitutional dislike of the particular kind of drudgery that every mathematician has to face, the drudgery, i.e., of hunting down every soupçon of inaccuracy? Unlike an artist in words, the mathematician is always right or wrong. There is no middle course, no room for difference of opinion. He cannot evade the issue by taking refuge in a fallacy.

His exclusion from inner scholarly circles undoubtedly wounded him grievously: how far could this wounded pride have been responsible for his actions? Could he have been really conscious of his mathematical ignorance, but did he hope that his gifts as a dialectician would enable him to conceal that ignorance by storming his opponents with lampoon and satire? Again, who can say?

Poor Hobbes! If he did nothing else he added to the gaiety of the world.

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4. *Famous Problems in Elementary Geometry*, Felix Klein, trs. Beman and Smith.
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CHAPTER VII

The Fourth Dimension

1. Dimensions and Totalities

" But *where* is Heaven and *where* is Hell?" asked the one-time puzzled student of theology. Quite seriously, perhaps, the lecturer may have pointed upwards for the former and downwards for the latter. " But how can that be?" was the natural reply; " are the two directions reversed for people on the other side of the globe?"

Some people find the puzzle a puzzle no longer. They have conferred upon space a fourth dimension, and in it they have located both heaven and hell. These people are not humorists but very serious people indeed.

There is a big family of related words in English, French, Latin, and Greek, all relating to *measures* and *measuring*. The word *meter* may be regarded as a parent word, and the English words *measure*, *mensuration*, and *dimension* as three of its children. To take the *dimensions* of a thing, we *measure off* that thing. All " real " things have *three* dimensions, length, breadth, and thickness, but these terms are not quite constant in their usage; for instance, we talk of the length, breadth, and thickness of a brick; the length, breadth, and height of a house; the length, breadth, and depth of a trench; the height, width, and depth of a cupboard (where depth refers to the front-to-back dimension); and the terms " breadth " and " width " are often used indifferently for the same dimension. The variations in usage are, however, quite familiar, and it is common knowledge that there are always

three dimensions concerned, never fewer, and never more.

In geometry, we speak of *points*, *lines*, and *surfaces*, but, strictly speaking, these are all abstractions, and have no real existence. A *point* has no dimensions, and therefore has no size or magnitude whatsoever. A *line* has one dimension, viz. length; it has no breadth whatever. A *surface* has two dimensions, viz. length and breadth: it has no thickness whatever. On paper we represent a *point* by a dot; this usually consists of a number of tiny particles, perhaps of black lead or ink, every particle of three dimensions. Similarly we represent a *line* by a visible mark, consisting of a string of such particles, again all of three dimensions. So when we think of a surface we try to visualize it, and we are probably therefore led to think of the superficial layers of three-dimensional particles on the outside of the solid or liquid we are considering. It is *convenient* to think of a dot as a point, of a pencil mark as a line, and of the visible part of a solid or liquid as a surface, though by so doing our arguments about them are likely to be invalidated. Geometrical points, lines, and surfaces are all fictions.

We may truthfully say in geometry that a moving point traces out a line and we may then help our imagination by running the black end of a pencil over a sheet of paper; we may also truthfully say that a straight line moving parallel to itself traces out a surface, and then help our imagination by rolling a thin rod of carbon over a sheet of paper; and we may truthfully say that a plane surface moving perpendicularly to itself traces out a solid in space, and then help our imagination by piling up sheets of paper into a thicker and thicker block. But it is impossible to imagine *geometrical* points, lines, and surfaces really doing these things, because they are all fictions; they defy the imagination, for the imagination can only picture things of three dimensions. We *must* distinguish between the real and the abstract, though this is not an easy thing to do, inasmuch as all our lives we have thought of points, lines, and surfaces as things which we can *see*. In doing this we have not been guilty merely of

the quite pardonable error of magnification; the real error is that of self-deception. In trying to magnify a *point*, we try to magnify *nothing*, but we feign satisfaction by surreptitiously putting under our mental microscope a three-dimensional thing and magnifying that.

The same terms, point, line, and surface, have to do duty both for the abstract geometrical things and for the substituted concrete things used to represent them to the eye. In this chapter, the reader must clearly distinguish between the two usages. And when referring to surfaces, we shall usually mean flat or *plane* surfaces (not curved surfaces), and shall speak of them as *planes*.

The position of any point in a straight *line* is determined by a *single* measurement, viz. the distance from one end of the line, this end being regarded as a zero-point. The position of the given point is therefore given by a *single number*. It is because a single number suffices to determine the place of a point in a straight line that we say a straight line is *one dimensional*.

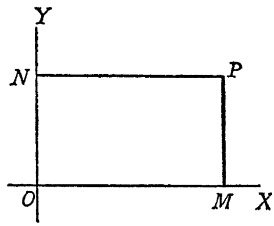

Fig 30

The position of any point, say P, in a *plane* is determined by *two* measurements. For instance, any point on this rectangular page may be determined by the perpendiculars from it to any two adjoining edges. The position of the point is therefore given by *two numbers*, viz. those representing the lengths of the perpendiculars. If the plane is of unlimited extent, we should adopt, quite arbitrarily, some zero point, O, and from it draw two lines, say OX and OY, at right angles to each other, called the axes, and drop perpendiculars from the given point on these. In fig. 30, PM and PN are the two perpendiculars, but in practice we should draw only PM, since PN is equal to OM. It is because two numbers suffice to determine the position of a point in a plane that we say a plane is *two-dimensional*. Descartes saw that, because every

point in a plane could be determined in this way, it was a very simple matter to treat geometry algebraically.

The position of any point P in *space* is determined by *three* measurements. From any arbitrarily chosen zero-point, O, three lines at right angles to one another, say OX, OY, and OZ, are drawn, like the three edges which meet in a corner of a rectangular box, giving the three axes (fig. 31). The three axes determine the three planes corresponding, respectively, to the floor of the box (shaded), the shorter side of the box (shaded), and the front of the box (ZOXW, not shaded). From P, perpendiculars may be drawn to the

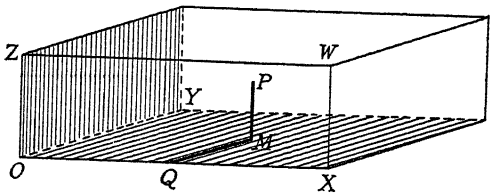

Fig 31

three planes, but, in practice, PM is drawn to the OX, OY plane (the floor); a second MQ, is drawn to OX; and OQ is the equivalent of a third drawn from M on OY (cf. fig. 30). The position of P is therefore determined by *three numbers*, viz. those representing the lengths of the perpendiculars. It is because three numbers suffice to determine the position of any point in space that we say space is *three-dimensional.*

The *total number* of points in a straight line may be called a *totality*. We may therefore think of a straight line as a *totality of points*, or a *one-dimensional totality*. Similarly, we may think of a plane as a *two-dimensional totality*, and of space as a *three-dimensional totality*.

A convenient limited plane to discuss is a square; and a convenient limited volume of space, a cube. Every schoolboy can see from his ruler that a foot consists of 12 inches; from a sheet of paper he can cut inch squares, and fit 144 of these together, 12 rows of 12 squares each, to make a square

foot; and from a box of toy bricks cut in the form of inch cubes, he can build up 1728 into a cubic foot of 12 layers, each layer consisting of 12 rows of 12 cubes each. The numerical relations of length, area, and volume are now clear to him; 12 linear inches make 1 linear foot, 12×12 ($=12^2$) square inches make 1 square foot, and $12 \times 12 \times 12$ ($=12^3$) cubic inches make 1 cubic foot. His elementary algebra enables him to generalize with units of any length, and with any magnitudes, great or small. If, for instance, a given line is a totality of n points, a square constructed on that line as an edge is a totality of n^2 points, and a cube constructed on this square as a base is a totality of n^3 points.

Presumably the world-space in which we live is a three-dimensional totality, and any point in it may be determined by three measurements, viz. the lengths of the perpendiculars from the point to three conveniently chosen planes at right angles to one another, the planes meeting in a point like two adjacent walls and the floor of an ordinary room. As we shall see later on, the word *continuum* is sometimes used instead of totality; its significance is not, of course, quite the same, though in this chapter the difference is of little importance.

2. The Advocate of the Fourth Dimension

The advocate of a Fourth Spatial Dimension begins by asking, "If x represents a one-dimensional continuum, x^2 a two-dimensional continuum, and x^3 a three-dimensional continuum, what does x^4 represent?" He forgets that algebra is just a useful scheme of generalized arithmetic which was used by Descartes as an instrument for solving problems in geometry; he tries to invent a new geometry that will give a spatial meaning to x^4, but he finds at once that the space in which we live will not meet the case.—If on a horizontal plane surface, say a table-top, we draw two intersecting straight lines perpendicular to each other, and through the point of intersection we draw a third line, perpendicular to

the table-top and therefore perpendicular to the other two lines, evidently all three lines will be perpendicular to one another, each being perpendicular to the other two. All three lines may be extended indefinitely in both directions, and three planes may be passed through them, much like the floor and two adjacent sides of our box, but extended indefinitely. From *any point whatsoever* in space, three perpendiculars may be drawn to these three planes, respectively, so that the whole of the space in which we live must be contained within the three-dimensional scheme.—How then is the fourth dimension advocate to obtain his extra dimension? Quite unblushingly he tells us to draw, through the point of intersection of the other three perpendicular lines just referred to, a *fourth* line perpendicular to the other three, all four to be perpendicular to one another, in fact. When challenged that the drawing of such a line is utterly impossible, is he dismayed? Not a bit. He still maintains that it *must* be possible to draw it, for does not its name x^4, stand out boldly for all the world to see? If there is a *name*, surely there is a *thing* to correspond! He tells us that our inability to draw this necessary fourth perpendicular line is due to the present imperfection of our senses. And to support his thesis he brings forward a medley of ingenious and ingenuous arguments that together make one of the merriest tales known to mathematics.

3. Symmetrical Geometrical Figures, Plane and Solid

Before giving details of some of these arguments, we must first refer to certain types of geometrical figures.

Hold your open right hand in front of a looking-glass and look at the image of the palm. Compare this image with the palm of your real left hand. They are exactly alike. For instance, the two thumbs point in the same direction. Thus the *image* of your right hand is a left hand.

Place a pair of gloves side by side on the table, backs upwards, thumbs touching. Each is the image of the other, as may be checked in a looking-glass. Turn the left-hand glove inside out; it has become a right-hand glove, and you have now two right-hand gloves, no longer images of each other but *like* each other.

Let a drop of ink fall into the crease of a sheet of note-paper, and press down fairly hard in order to make the ink run and form a pattern. Open out; the two half-patterns are right- and left-handed; each is the image of the other. Fold the paper on its crease again and hold up to the light; the two half-patterns are seen to fit over each other exactly.

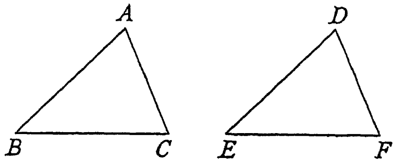

Fig. 32

Right- and left-handed patterns that can be folded exactly together in this way, and are thus images of each other, are said to be " symmetrical ". The dividing line represented by the crease is called the " axis of symmetry ", and the opened out double pattern is said to be " symmetrical with respect to the axis ". Such a doubled pattern can always be imagined to spin on the axis of symmetry because of the perfect balance.

When the schoolboy talks about two " congruent " triangles, he means triangles alike in all respects—lines the same length, angles the same size, areas the same. But such a pair of triangles may or may not be symmetrical. ABC and DEF (fig. 32) are congruent but not symmetrical; GHK and LMN (fig. 33) are congruent *and* symmetrical. If these triangles were cut out in paper, ABC could be picked up and put down again over DEF and made to fit exactly. But GHK could not similarly be picked up and fitted over LMN;

to make GHK fit it would have to be *turned over* before being placed on LMN, or it might be rotated on the axis of symmetry (the dotted line in the figure) This is an important principle; two symmetrical figures cannot be made to fit

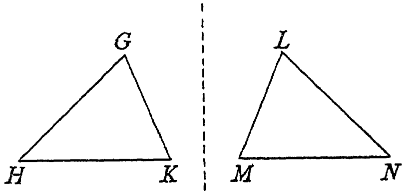

Fig 33

exactly together unless one of them is either turned over, or rotated through 180° on its axis of symmetry.

We may have three-dimensional symmetry as well as two-dimensional. Let the reader cut out in paper two figures

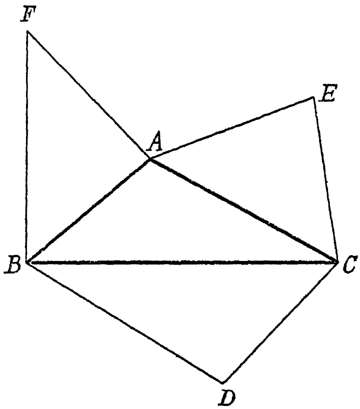

Fig 34

exactly like fig. 34. (Observe that AE = AF, BF = BD, CD = CE). Cut the paper half-way through its thickness in the lines AB, BC, and CA, in the one case on the front and in the other case on the back (the cutting makes neat folding possible). Fold the paper on these cut edges until D, E, and

F meet in a point, in the one case above, in the other below. The result is two pyramids which in all lengths and all angles are congruent yet which cannot be made to coincide (fig 35). They are right-handed and left-handed, like a pair of gloves, symmetrical, or like an object and its image in a mirror. Now just as it was impossible, by simple displacement, to make the two symmetrical triangles (fig. 33) coincide and fit together exactly, so it is impossible to make these two symmetrical three-dimensional pyramids coincide and fit together exactly. But we were able to make the two

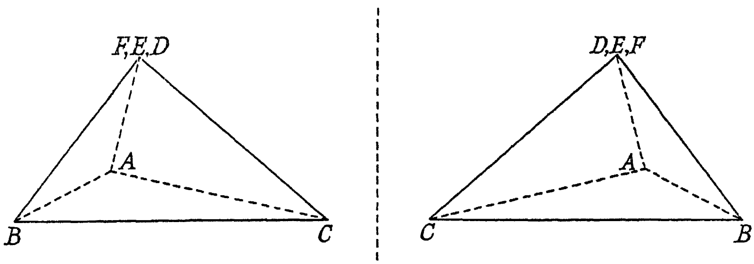

Fig 35

symmetrical plane triangles coincide and fit together exactly either by turning one over or by rotating it through 180° on its axis of symmetry. We cannot adopt the same expedient in order to get a similar result with the pyramids. But just as we made a right-hand glove form a left-hand glove merely by turning it inside out, and thus made an ordinary pair of symmetrical gloves into a similar pair, so, if we turn one of the pyramids inside out, we convert a symmetrical pair into a similar pair. The actually turning inside out is easily effected with either of the paper pyramids if the edges have been left unsealed; it is a case merely of folding back its triangles the reverse way.

If we conceive of a glove to be made up of a single layer of contiguous particles each of which could be turned over independently through 180°, the inside and the outside of the glove would clearly be interchanged, and thus the glove would

be turned "inside out" (or outside in). But a right-hand glove would not by this means be turned into a left-hand glove; it would remain a right-hand glove.—Some four-dimensionists call this "turning over"; others call it "turning inside out". We may now return to them and their arguments.

4. Fallacies from Flatland

They tell us that our difficulty of conceiving a space of four dimensions will largely disappear if we consider the difficulty experienced by imaginary two-dimensional beings in imaginary two-dimensional space who are receiving from three-dimensional beings (ourselves) a lesson on the nature of three-dimensional space. To this imaginary two-dimensional space the name "flatland" is usually given, and to the inhabitants, the name "flatlanders". Flatland is supposed to be just a plane of infinite extent, and flatlanders are supposed to be two-dimensional beings endowed with intelligence; they have length and breadth only—squares, triangles, circles, ellipses, ovals, and other shapes, and they are utterly unconscious of any third dimension. They are conscious of right and left, backward and forward directions, but not of up and down. They cannot raise or lower their heads, for they have no space above or below. Their houses are enclosures of mere straight or curved lines. All that they can see are lines and points. They can move round a triangle and discover its shape and dimensions, and they could discover the sameness of two triangles exactly alike by pushing the second into the same position that had been occupied by the first. But they could not discover the sameness of two symmetrical triangles, for they could not turn one of them over, or rotate one on an axis of symmetry, because that would mean moving the triangle right out of the space in which they live. If a three-dimensional body, say a sphere, passed through their country, they would "see" first a

"point", then a small circle which would push out of its way any obstructing flatland thing, then a larger and larger circle, and then a smaller and smaller circle, until the sphere had disappeared. They would be utterly unconscious of anything more than a plane circle passing through their country (fig. 36). Any three-dimensional being (one of ourselves) looking down upon flatland would be looking down on beings with only length and breadth, and could therefore see and touch any part of the internal anatomy of those beings. He might suddenly appear as a sort of ghost in a flatlander's house, appearing mysteriously inside without

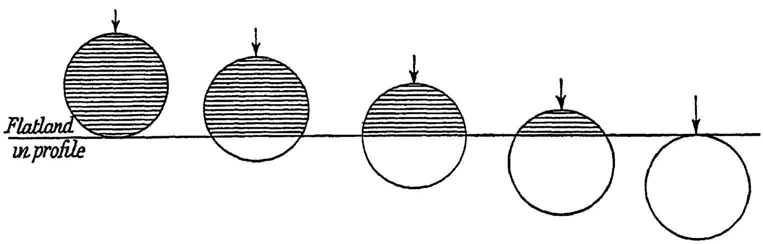

Fig 36

having passed through the enclosing walls. All that the flatlanders would see of him, however, would be the outlines of a succession of cross-sections of the visitant's body. It would never occur to them to do what our microscopists are constantly doing—to visualize a solid form by reconstruction from a succession of sections. To the flatlanders, such a visualization would be altogether contrary to their experience, and no amount of explanation from the mysterious visitant from the unknown three-dimensional world would make them understand.

This fable of flatland forms the jumping-off ground of our four-dimensional friends. They argue from analogy. Our difficulties in grasping the nature of four-dimensional space are, they say, strictly analogous to the difficulties of the flatlanders in understanding the nature of our own three-dimensional space.

5. The Four-Dimensionists' Geometry

Arguing from analogy they try to work out a complete geometrical scheme. The favourite plan is to consider a single "unit" in each kind of space, and to attempt to develop a unit of higher order from a unit of lower order.—Let the unit in one-dimensional space consist of a *line* AB, 1 foot long, consisting of x points (fig. 37 (*a*)). On this line we may construct a unit in two-dimensional space, viz. a *square* ABCD. Since AD, like AB, consists of x points, the square may be considered to consist of x^2 points in all (fig. 37 (*b*).

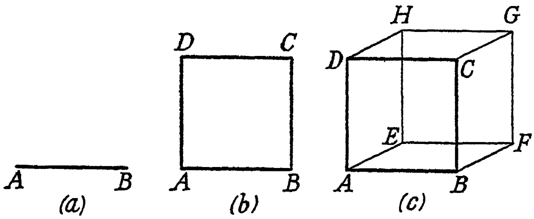

Fig. 37

We may now regard this square as the face of a cube in three-dimensional space. Just as we drew AD perpendicular to AB and completed the square ABCD, we now draw AE also perpendicular to AB and complete the solid cube ABCDEFGH. Since the face of the cube contains x^2 points, and since the edge AE of the cube contains x points, the cube contains x^3 points in all; and since the face of the cube contains x lines, the cube contains x^2 lines in all. We may now make up a little table:

	Points	Lines	Squares	Cubes
Line, 1-dimensional unit.	x	1	0	0
Square, 2-dimensional unit.	x^2	x	1	0
Cube, 3-dimensional unit.	x^3	x^2	x	1

Examine the table and note how the same quantities are repeated diagonally. Why then, not continue thus?

	Points	Lines	Squares	Cubes
Line, 1-dimensional unit.	x	1	0	0
Square, 2-dimensional unit	x^2	x	1	0
Cube, 3-dimensional unit.	x^3	x^2	x	1
Hypercube, 4 dimensional unit.	x^4	x^3	x^2	x

At any rate, this is what our four-dimensionist friends suggest. But can we construct a four-dimensional unit *geometrically*, i.e a unit consisting of x^4 points, x^3 lines, x^2 squares, and x cubes? It seems impossible, for how can we draw from A a *third* line perpendicular to AB? The only two possible perpendiculars AD and AE have already been drawn (fig. 37(c)).

This difficulty does not baffle the four-dimensionist. He tells us to consider not the contents but the *boundaries* of the units. We are to cut through the periphery of the square ABCD at one of its angles, say D, and stretch it out into a straight line (fig. 38). The original linear unit AB now has

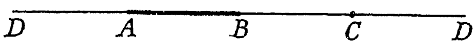

Fig 38

one linear unit at each end (AD and BC) *and one more* (CD) *beyond.*

The next step is to cut through the edges of the cube and so "develop" it, in order to show the six faces in one plane (fig. 39). The original square ABCD has one square on each of its four edges (AEFB, BFGC, CGHD, DHEA), *and one more* (GFEH) *beyond.*

The four-dimensionist now argues that the four-dimensional unit we are seeking may be constructed in an analogous fashion to the three-dimensional unit, viz. by continued

"development". Just as we added squares to the four edges of our original square, and *then one more beyond*, so we may

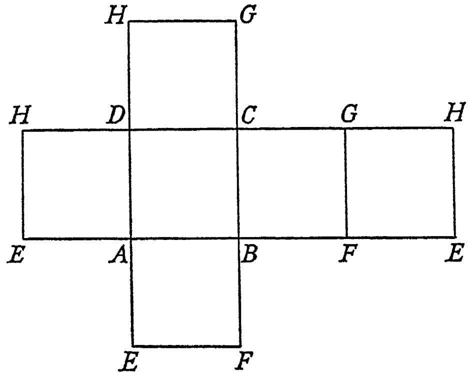

Fig 39

now add cubes to the six faces of our original cube, and *then one more beyond* (fig. 40).

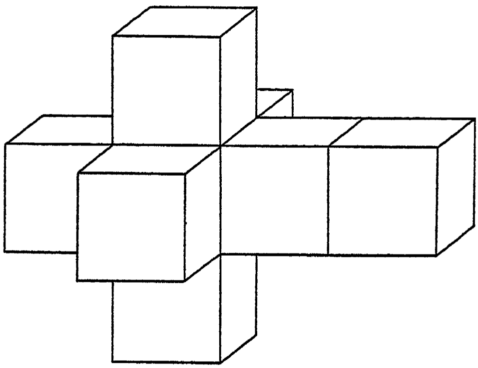

Fig 40

This block of 8 cubes is said to form the four-dimensional unit, but unfolded or "developed" into three-dimensional space, though necessarily shown pictorially here on the plane of the paper. Thus unfolded, the unit is best examined from

a model made by gluing eight little wooden cubes together. The fanciful names *tesseract* and *hypercube* have been given to the unit.

The reader may be puzzled, and no wonder! But the four-dimensionist's main suggestion is quite easily understood.—Fig. 39 shows a three-dimensional solid cube unfolded or developed into a two-dimensional net. Fig. 40 shows what the four-dimensionist claims to be a four-dimensional tesseract unfolded or developed into a three-dimensional net. But there is this fundamental difference: the three-dimensional cube has been actually made, and *then* unfolded or developed into a two-dimensional net; *but the four-dimensional tesseract has not been made at all.* Its so-called three-dimensional net has not been unfolded or developed from the real thing but is just a mere analogical construction, and nothing more. It cannot be folded up into a real four-dimensional unit, as the six squares (fig. 39) can be folded up into a real cube. When the four-dimensionist asserts that the tesseract net *can* be folded up, he is talking nonsense. He admits—very ruefully—that he has not yet succeeded in folding it up, but he claims still to be confident! It must be remembered that his precious tesseract is only a *unit*, and the folding up has to be done in such a way that identically similar units will fill the whole of a particular portion of four-dimensional space, just as ordinary cubes can be packed together to fill a particular portion of three-dimensional space, or squares to fill a plane.*

Not all four-dimensionists see the same visions when gazing into four-dimensional space!

An alternative scheme (cf. p. 153) is to tabulate the number

* Professor Manning's prize-winning essay states that while in our space there are five regular polyhedra (tetrahedron, cube, octahedron, dodecahedron, icosahedron, in hyperspace there are six hypersolids, the tesseract being one, the sixth is bounded by 600 tetrahedrons (how wonderful!) Victor Schlegel made "nets" of all six, they were complicated three-dimensional things, analogically suggested by the two-dimensional nets of our five three-dimensional polyhedra. They were made by Brill of Darmstadt, and then by another German firm named Rother, but they are no longer obtainable. One enthusiastic four-dimensionist sent me the two diagrams shown in fig 41, and gravely told me that if I made 120 of them they would fold up into a hypersolid.

of corners, edges, faces, and cubes, of similar geometrical figures in one, two, and three dimensions, continue the table *one step beyond*, and so arrive at the number of corners,

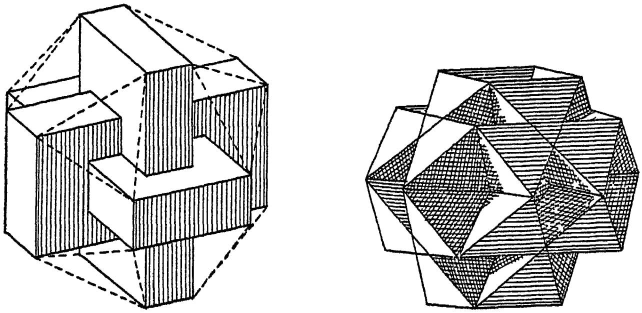

Fig 41

edges, faces, and cubes in the four-dimensional unit. We have now merely to plan a geometrical figure showing these numbers of corners, edges, faces, and cubes, and there is our hypercube, or four-dimensional unit! One such fanciful figure is shown in fig. 42. It looks like a cube suspended within a cube. It is easy to trace six other solid figures — squat truncated pyramidal slabs, between the six faces of the smaller cube and the six corresponding faces of the larger cube; FBCG*fbcg* is one. The eight solid figures, viz. the two cubes and the eight pyramidal slabs, are supposed to show, *in projection*, the eight cubes of a tesseract. You don't believe it? Well, count up the points (corners), lines (edges), squares, and cubes; do they not fit perfectly into a simple tabular scheme?

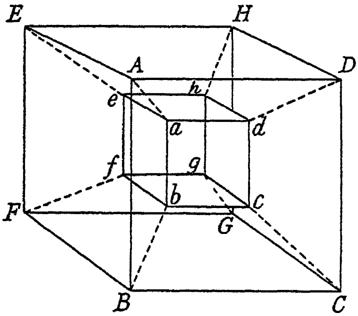

Fig 42

In short, all that we need do in order to determine the nature of space of even still higher dimensions than four, is to continue the series in our table worked out from our simple geometrical figures in one, two, and three dimensions. How simple it all is! If we draw geometrical figures correctly showing the estimated number of points, lines, planes, cubes, tesseracts, &c., are we not justified in assuming that the figures truly represent units of n-space, or projections of these figures, or projections of those projections, or projections of *those* projections? If our arithmetic is right, how can our geometry be wrong?

6. Four-Dimensionist Enthusiasm

In 1909 a Prize was offered, under the auspices of the *Scientific American*, for the best popular explanation of the fourth dimension, and Professor Henry P. Manning of Brown University, and Professor S. A. Mitchell of Columbia University, were appointed judges. Of these essays, 22 were published in book form under the title *The Fourth Dimension Simply Explained.* Mr. C. H. Hinton and Dr. Schofield have also interested themselves in the subject. A few quotations will be of interest:

1. "Conceive a solid of three dimensions. If this solid were to become infinite, it would fill the whole of three-dimensional space. But it would not fill up the whole of four-dimensional space. It would be to four-dimensional space what an infinite plane is to three-dimensional space. There could be in four-dimensional space an infinite number of such solids, just as in three-dimensional space there could be an infinite number of infinite planes. Thus, lying alongside our space there can be conceived a space also infinite in all three directions. To pass from one to the other, a movement has to be made in the fourth dimension, just as to

pass from an infinite plane to another a motion has to be made in the third dimension." *

Lying alongside our space! *What* an imagination!!

2. "If we connect all points of our space (a 3-space) with an assumed point outside it, then the aggregate of all the points of the connecting lines constitute a four-space (hyperspace). Again, just as a point may generate a line, just as a line moving outside itself generates a surface, and a surface moving outside itself generates a solid; so a solid moving outside of our space generates a hypersolid or portion of hyperspace. Or hyperspace may be conceived as generated by our entire space moving parallel to itself in a direction not contained in itself, just as our space may be generated by the similar motion of an unlimited plane.

"Solid geometry is much illuminated by the geometry of hyperspace." †

Illuminated!

3. "A line may be considered as an infinitely thin slice of a surface, a surface as an infinitely thin slice of a solid, and so a solid as merely an infinitely thin slice of an extra-solid (four-dimension figure). Expanding this idea to the whole universe, we see that it follows, as a matter of course, that an infinite number of two-dimensional universes is capable of being contained in our space and, similarly, a universe of four dimensions would of necessity contain an infinite number of universes such as ours." ‡

We note that all this "follows as a matter of course". Clearly a universe of *five* dimensions would be a pretty big place, and one of *n* dimensions . . . ?

4. "If we try to think of a point moving from the inside of a sphere to the outside without passing through the surface, the thing is inconceivable to us, and so we say it is impossible; but if we assume a fourth dimension, then the point could, so to speak, 'jump over' the surface and appear again in

* C. H Hinton, *What is the Fourth Dimension?* p 26

† From the Prize-winning Essay by Colonel G D. Fitch in *The Fourth Dimension simply explained.*

‡ *op. cit.*, from the Essay by Crepuscula Sublucent, pp 135–6.

three-dimensional space outside the sphere. The same is true of any such closed surface in three dimensions. If a prisoner could make use of motion in a fourth dimension, we know he could escape from the inside of a closed cell, without touching the sides at all." *

Why did not the writer provide a sketch, to illustrate that "jump-over"? How he would have earned the gratitude of prisoners!

5. "A being, able to move in four dimensions, could get out of a closed box without going through the sides, for he could move off in the fourth dimension, and then move about, so that when he came back he would be outside the box." †

But why has he to go for a walk and then come back?

6. "If some of us were locked in an airtight room, we could never get out until an opening were made in one of the six bounding surfaces. But analogy says that a four-dimensional being might pass us through the fourth dimension and set us on the outside of the room without disturbing any of the bounding walls." ‡

Thus not only would the four-dimensional being himself get out but take with him a batch of three-dimensional friends!

7. "Imagine a being in a cubic three-dimensional figure, say a box having solid corners on all of its six sides. There is no conceivable way of getting out of such a box save by passing through one of the six sides, yet a fourth-dimensional being could move the being confined in the box into the fourth dimension and so out of the box without passing the being through the sides of the box." §

The closed box seems to contain a store of four-dimensional space, inasmuch as the confined being is "moved into" it and *so out* of the box!

* *op. cit.*, Essay by N, p. 123

† C A. Hinton, *What is the Fourth Dimension?* p 27

‡ *The Fourth Dimension Simply Explained*, Essay by Richmond.

§ *op cit.*, Essay by Quesnel, p. 116.

One of Professor Manning's essayists, "Incredulus Odi", is very sceptical about the fourth dimension, and maintains that no real explanation has been put forward concerning any modification of physical laws in spaces of higher order, and that until such explanation is given it is impossible to believe that in four-dimensional space we can extract the contents of an egg, or pass an external object into an egg, and at the same time leave intact the continuous material structure that we call the shell.

Professor Manning himself criticizes his contributor. He says, "there is no question of the possibility in space of four dimensions of entering or passing out of what we call a tightly shut box or room, of removing the contents of an egg without disturbing the shell". He distinguishes between "turning over" a glove and "turning it inside out" (see p. 149). A right glove "turned over" in a space of four dimensions, he says, becomes a left glove, but is "not turned inside out". And he adds, "Even Schubert makes the mistake in his article, *The Fourth Dimension.*" * Professor Schubert was one of the most eminent mathematicians in Germany, and his deduction, which of course is drawn from analogy, coincides with that of practically every serious student of the allegory of the fourth dimension. He himself is no believer in the fourth dimension, but he does very clearly show what consequences flow from fourth-dimensional assumptions. Professor Manning himself explains how "an object can pass out of a closed room or box without penetrating the walls", in this way: "A point starting from the centre of a sphere in our space and moving off on a line perpendicular to our space will not approach any portion of the surface of the sphere but will move away at the same rate from all points of this surface." †

Ah, that elusive perpendicular! Why should a chicken, just ready to hatch, trouble to break through its shell? The mother hen might so easily instruct it to follow the route of

* See Schubert's *Mathematical Essays*, p. 91.

† *The Fourth Dimension Simply Explained*, p. 23.

the aforesaid perpendicular; then it would never "approach any portion" of the shell, but would get safely outside it, all the same.

It was the symmetry of a pair of gloves and the conversion of one of them into the other by either "turning it over" or "turning it inside out", that suggested to four-dimensionists solutions of all sorts of right- and left-hand problems. For instance, the term "isomer" is used by chemists to denote the phenomenon of the existence of two or more different substances having molecules made up of the same number of the same atoms. There is evidence to show that these atoms are grouped in different ways, right- and left-handed (compare the two pyramids, fig. 35), and that these different symmetrical arrangements lead to the different properties of the different substances. How were the different arrangements brought about? The four-dimensionist is prompt with a solution.—Assume that the newly born molecule of one chemical substance stepped by chance into the fourth dimension; it would necessarily "turn over" or "turn inside out": and there you are! Again, all turbots have their faces slewed round to the left, all soles to the right; which of the two baby fish strolled by accident into the fourth dimension, and so "turned over" or "turned inside out", i.e. did a turbot become a sole or a sole a turbot?—the four-dimensionists hesitate to say. Once more: some molluscs coil in a right-handed direction, others in a left-handed direction; some plants twine in a right-handed direction and some in a left.—Admit the existence of the fourth dimension, and all our difficulties in understanding these curious alternatives adopted by nature vanish in a twinkling. A common corkscrew is made as a right-handed spiral, but conjurers sometimes use one which is left-handed, constructed, no doubt, in a four-dimensional workshop.

7. Spiritism * and the Fourth Dimension

The Spiritists were quick to seize upon the idea of the fourth dimension, in order to bring conviction to the minds of the waverers in their flocks. It was so easy to make capital out of that sealed room, for would not such a room, with its hidden supply of four-dimensional space, suggest to certain types of people a rational and satisfactory explanation of various forms of spiritistic phenomena? It would, for instance, explain visible ghosts and the presence of invisible spirits; it would explain moving tables, the animation of broomsticks, the miraculous throwing about of material objects, spirit-rappings, the ordeals of witches, the untying of knots in a closed string, insensibility to injury, walking over red-hot coals, the music of the invisible spirits; it would explain spirit-writing, clairvoyance and divination. It is well-known that all such phenomena are easily produced by illusionists, who always tell their audiences frankly that the phenomena *are* illusions (they were the stock-in-trade of the famous Maskelyne family at the Egyptian Hall, Piccadilly, and St. George's Hall, Regent Street, for half a century); and it is equally well known that, when the phenomena are put forward by money-making spiritists as supernormal phenomena mysteriously associated with the fourth dimension, they represent trickery and humbug of the worst type.

It was the Leipzig professor, Zöllner, who first seriously proclaimed the fourth dimension to be the abode of spirits. He was in no sense a charlatan but a research worker of more than ordinary distinction, and his amazing naïveté in accepting the fourth dimension as a reality is almost incomprehensible. He held that this higher space is inhabited by intelligent beings who can and do influence for good and evil the human beings in experimental three-dimensional

* This term is obviously preferable to the more commonly used term "spiritualism"

space. Plato's "ideas" Zollner regarded as spatial objects of more than three dimensions and as "real existences", and he also regarded Kant's "thing-in-itself" as a real thing in the fourth dimension. Carl Du Prel went even further than Zöllner: "Just as the shadows of three-dimensional objects cast on a wall are controlled in their movements by the things whose projections they are, in the same way it is claimed does there exist at the back of everything in this sense-perceptible world a real, transcendental, four-dimensional 'thing-in-itself' whose projection in the space of experience is what we falsely regard as the independent thing. Thus, every man besides existing in his terrestrial self also exists in a spiritual or astral self which constantly accompanies him in his walks through life, and whose existence is especially proclaimed in states of profound sleep and in the conditions of mediums."—But Du Prel does not tell us how we can induce our transcendental "thing-in-itself" to come out of his hiding-place in the fourth dimension and allow himself to be seen in the third. Which is a great pity.

Ulrici went even further than Du Prel. He thought he saw in the doctrine of Spiritism a means of strengthening Christianity, especially the belief in immortality, and in his hands Spiritualistic and Christian beliefs became so intermingled as to be hardly distinguishable.

Ulrici wrote a tract, *Spiritualism so-called, a Question of Science*. A crushing reply, entitled *Spiritualism, a Question of Science so-called*, was written by Wundt: "Physically the souls of the dead come into the thraldom of certain living beings who are called mediums. These mediums are, for the present at least, a not widely diffused class, and they appear to be almost exclusively Americans. At the command of these mediums, departed souls perform mechanical feats which possess throughout the character of absolute aimlessness. They rap, they lift tables and chairs, they play on the harmonica. Intellectually, the souls of the dead enter a condition which, if we are to judge from the

productions which they deposit on the slates of the mediums, must be termed a very lamentable one. These slate-writings belong throughout to the category of imbecility": and so on. Wundt then laments the demoralizing effect which spiritism exercises on those who practise it.*

Needless to say, the spiritistic four-dimensionists have sought support from the Bible. They affect to believe that the references to the length, breadth, depth, and height in Job (xi, 8–9) and Ephesians (iii, 18) specifically concern space of four dimensions, ignoring the obvious inference that height and depth are really alternative terms for the same dimension. They see references to a four-dimensional world of spirits in the Gospel of St. John (xii, 32; xiv, 2, 3, 28; xvi, 5, 13). They assign to the fourth dimension the fiery furnace, the transfiguration, and the resurrection; and so forth.

Perhaps the most interesting case of an Englishman whose earnest belief in the fourth dimension admitted of no sort of doubt was Dr. A. T. Schofield, a fashionable physician practising in Mayfair thirty or forty years ago. Schofield was an attractive man, always immaculately dressed, with spotless gaiters and a gay "buttonhole", the confidant of half the fashionable ladies of London. He was an ardent Churchman and a devout Christian. Though in no sense a mathematician, he became a keen four-dimensionist, and his little book *Another World, or the Fourth Dimension* (which was dedicated to a distinguished chemist, Professor J. H. Gladstone †) is still eminently readable. Its tone is unexceptionable. Its tenor may be gauged from two short quotations: (1) "Surely the study of what we term this fourth dimension far transcends the highest earthly subjects, and dwarfs to their proper level all objects of human ambition, for we see at once that the lowest inhabitant of the fourth dimension is necessarily of a different and higher order than the greatest monarch in the third." (2) "The power whereby Christians

* Cf. Schubert, *op. cit*, p 107.

† Whose daughter became the wife of Mr. J. Ramsay Macdonald.

are lifted out of the third into the fourth dimension, mentally, at any rate, is graphically portrayed in Colossians ii, 20—iii, 4. They are there spoken of as dead and risen with Christ (into the fourth dimension), and are to be occupied with the superior glories of their new sphere." *

Pathetic? Perhaps. But who can fail to be impressed with the sincerity of the man's convictions?

A recent book on the Fourth Dimension is, *What is the Fourth Dimension? Reflections inspired by a pair of Gloves.* One extract must suffice: "The idea that heaven is quite real, and at the same time is in no definite direction from the earth, is a very widespread one, and may well be shared by members of other faiths outside the Christian communion. In a three-dimensional world, it is a paradox, or worse, it is a contradiction. But admit the fourth dimension, and the whole difficulty clears up at once. The extra dimension supplies something which exactly bridges the gap. Heaven can now be thought of just as before—a real place with no immediately definable direction, but with the feeling that there is now no paradox, no contradiction. We cannot point to heaven, because we are physically limited in our pointing to directions within the ken of our three-dimensional limitations. But the direction can well be there. There is now no need for the apostle of orthodoxy to feel a little awkward over his position. The eye of faith has seen and accepted for hundreds of years what the eye of science has only just discovered."—The writer, Mr. C. W. R. Hooker, adopts a generally cautious attitude but the last sentence in the passage we have quoted is misleading. Science knows *nothing* of a fourth spatial dimension, and it does not claim to have made any discovery whatever concerning such a dimension.

* *op. cit.*, pp. 82, 90.

8. The Verdict

The four-dimensionists ask for judgment. What is to be the verdict?

Let the Essayist " Incredulus Odi " speak again: " Mathematical lines and plane figures do not, like matter, occupy space. If the supposititious beings in one- or two-dimensional space find any obstruction to their movements, it must be because they occupy space and therefore are really in three-dimension space, however little they extend in one or two directions. The supposition of a one-dimension or a two-dimension space is therefore impossible except as a mathematical abstraction and furnishes no basis for a belief in a fourth dimension."

Again. " No observation has ever discovered the existence of a fourth dimension in space, and it may safely be said that there is no reason for believing in its existence. . . . The same analogies and inferences on which the four-dimensionists depend would lead us to a fifth, a sixth, an *n*th dimension."

And again: " The four-dimensionists assert that a body would disappear on 'entering the fourth dimension'. This expression is manifestly unintelligible. Every body extends constantly in all the directions of space; we cannot think of it as 'entering the dimension' of length, breadth, or thickness, or of 'entering the fourth dimension' if there were one. The disappearances depend wholly on removal from the limited perceptive faculties of the supposed observers, but our normal perceptions are unrestricted in direction and extend to every point in space unless cut off by distance or by an interposed physical obstruction. If all the particles moved in the 'new direction' of the imaginary fourth dimension, the body would still retain its length, breadth, and thickness, and would still remain within the range of our perceptions."

These arguments are unanswerable, though Professor Manning himself tries to meet them (quite temperately and good-naturedly) in a footnote to the essay.*

Professor Schubert says: "Although most of the phenomena to which the Spiritualists appeal are founded on sense illusions, humbug, and self-deception, it cannot be denied that there possibly do exist phenomena which cannot be brought into harmony with the natural laws now known. Yet we have often seen that the progress of science has again and again revealed as natural what former generations held to be supernatural. If we adopt a point of view which regards it as natural for spirits arbitrarily to interfere in the workings of the world, all scientific investigation will cease, for we could never more trust or rely on experiment. . . . We recognize that the things which are termed supernatural depend to a great extent on the stage of culture which humanity has reached. . . . If there really is behind such phenomena as mind-reading, telepathy, and similar psychical phenomena, something besides humbug and self-delusion, what we have to do is to study carefully by serious experiments the success or non-success of such phenomena. . . . The high eminence on which the knowledge and civilization of humanity now stands was not reached by the thoughtless employment of fanciful ideas, nor by recourse to four-dimensional worlds, but by hard, serious labour and slow unceasing research." †

The accumulation of related facts in some branch of science often necessitates the invention of some provisional hypothesis which will harmonize the facts and link them together. The hypothesis may eventually settle down as an established theory, acceptable and accepted, and may even become recognized as something scarcely differing from objective fact. Well-known examples are the atomic theory, the wave theory of light, and the theory of evolution. Such hypotheses have always a multitude of hard and undisputed

* *op. cit*, pp 60, 61. † *op cit.*, Schubert, pp. 109 *seq*

facts to support them, though new facts may some day lead to their supersession.

But science is rarely guilty of stupidity. It is inconceivable that it would ever put forward the hypothesis, for instance, that the man in the moon sustains himself on cheese. Certainly the inventor of such an hypothesis might urge that he could *see* a man in the moon and that the moon *looks like* cheese. Absurd as such an hypothesis is, it is not so absurd as that of the fourth dimension, for the man in the moon has at least some sort of shape and the moon itself some sort of colour to support it, while the fourth dimension has not even the shadow of a shade to support it.

The fundamental fallacy underlying the fourth dimension is traceable to its basic assumption of a two-dimensional *real thing*. A geometrical plane, like a geometrical line and a geometrical point, is an *abstraction*, and *nothing more*. The finest hair is a three-dimensional thing, for it has thickness; the thinnest of thin paper is a three-dimensional thing, for it certainly has two sides and a thickness. To confer intelligence upon an indefinitely thin three-dimensional being is, for purposes of analogical argument, quite legitimate, but to confer intelligence on *nothing* is stupidity indeed. A two-dimensional " thing ", animate or inanimate, is a contradiction in terms, for a two-dimensional thing can have no existence at all. Even in our thoughts it is only a word, for it is certainly unimaginable and it is certainly inconceivable. The four-dimension analogy clearly breaks down absolutely. All four-dimensional things and all two-dimensional things may therefore wisely be allowed to fade away into the limbo of nothingness.

Earlier in the chapter we referred to the four-dimensionist's principal question: since x, x^2, and x^3 can be represented by geometrical figures, what geometrical figure represents x^4? —Descartes pointed out that all regular geometrical figures, whether representing lines, surfaces, or solids, could be shown in the form of related lengths, areas and volumes, all expressed *numerically*, and that these numerical relations

might be generalized and conveniently expressed *algebraically*. He made no such absurd suggestion as that the converse would hold good, viz. that because there is an algebraic symbolism of a degree higher than the third that therefore there was some kind of geometry to correspond. Descartes did *not* reason thus:

All fox-terriers are dogs;
Therefore all dogs are fox-terriers.

Yet this is precisely the kind of reasoning which characterizes the basic arguments of the four-dimensionists.

The fourth dimension is nothing more than a purely algebraic conception. Geometrically and spatially, it is all moonshine.

It does not at all follow, however, that, because the fourth dimension is a fiction, " space " is therefore the simple elementary thing which it is commonly assumed to be. During the present century some of our most eminent mathematicians have devoted much time and labour to the question of the nature of space, and even now a final solution of some of the underlying difficulties has not been reached. The difficulties are quite beyond the understanding of the non-mathematician, and here we can only hint at the nature of a few of them.

To begin with, we may refer again to the purely algebraic notions underlying " dimensions ".

As we have already said, a *single* number is sufficient to determine the place of a point in a straight line, and that is the reason why we attribute to the straight line or to any part of it a single dimension. But we may call *any* totality or system of infinitely numerous things *one*-dimensional, in which *one* number is all that is required to determine any one of these things from among the entire totality. Thus, *time* is a one-dimensional totality or system; any date can be named by a single number (not necessarily a whole number) measured from zero-point, say the birth of Christ. The circumference of a circle is another one-dimensional totality.

The totality of all circles that can be described through two fixed points is another. Still another is the totality of all concentric spheres having some one fixed point in space as a centre, the radii of which can be expressed by successive numbers of increasing magnitude.

The term *two*-dimensional is applied to all totalities in which *two* numbers are necessary and sufficient to determine some particular thing in a given totality. The simplest case is a plane; any point in it is determined by two numbers. As another example of a two-dimensional totality we may take all the straight lines that can be drawn through any point in space. For all these lines may be considered to pass through a plane, and since any point in the plane is determined by *two* measurements, the straight lines in question must form a *two*-dimensional totality.

The term *three*-dimensional is applied to all totalities in which *three* numbers are necessary and sufficient to determine some particular thing in a given totality. The simplest instance is that of ordinary space; any point in it is, as we have seen, determined by *three* numbers.

All conceivable spheres in space form a *four*-dimensional totality. For any particular point in space may be the centre of an infinite number of concentric spheres forming a one-dimensional totality as already stated. But *every* point in space may become the centre of such a totality of spheres, and since all these centres form a three-dimensional totality, it follows that all conceivable spheres in space form a *four*-dimensional totality, *four* numbers being necessary to determine any one.

A straight line of constant length which is allowed to assume every conceivable position in space gives us a *five*-dimensional totality. A lead pencil, if its thickness be ignored, may be thought of in illustration. One of the ends of the pencil may be imagined to occupy the position of every point in space; then we have a three-dimensional totality for this end alone. But, as we saw, when considering two-dimensional totalities, there proceeds from every such position

of this end, a two-dimensional totality of directions, and by considering the pencil to be placed lengthwise in every one of these directions, we shall obtain all conceivable positions which the second end can assume; hence the *five*-dimensional totality.

Similarly it can be shown that the totality of all equal plane rectangles which differ from one another only by their positions in space is *six*-dimensional. And the totality of all conceivable triangles in space is *nine*-dimensional, for *any three* points in space can be joined to form a triangle, and each of these points is itself a member of a three-dimensional totality.

We have used the term "totality" because its meaning is correctly suggested by the word "total", but the term in more common use is "manifold". Thus we may think of all conceivable spheres in space as a "quadruply extended manifold", and of space itself as a triply extended manifold, the elements of which are points.

Although it is not easy to visualize manifolds of more than three dimensions, the mathematician is easily able to express them in the form of algebraic equations of more than three *variables* (e.g. x, y, z, u, v), and he may draw useful diagrams. In dealing with these higher manifolds, he uses geometrical language freely. Frequently he even finds it helpful and suggestive to regard theorems in two or three dimensions as derivable by a sort of projection from simpler and more symmetrical theorems in "spaces" of higher dimensions. But he does *not* regard these higher manifolds as actual *physical* spaces.

If he does not think of his manifold as divisible into elements (say points or instants), he may use the term *continuum*. For instance, when dealing with Relativity problems, he refers to the *space-time* continuum. This continuum consists of four dimensions, three in space and one in time.—When we write an ordinary letter we begin by telling our correspondent *where* we are writing and *when*. The *place* is determined by *three* measurements and the *time* by one. But the

earth is then, as always, moving in both time and space, and the trouble is to find fixed zero-points from which to make our measurements. If we wished to determine the position of, say, a suspended electric bulb in a room, we have a convenient framework (floor and walls) from which to measure our distances. *What framework can we refer to when we wish to measure space-time?* That we must consider in the next chapter.

BOOKS FOR REFERENCE:

1 *Mathematical Essays*, Hermann Schubert, trs. by T. J. McCormack.
2 *The Fourth Dimension Simply Explained*, H. P. Manning.
3. *Scientific Romances*, C. H. Hinton.
4. *What is the Fourth Dimension?* C. H. Hinton.
5. *Flatland*, A. Square (E. A. Abbott).
6. *Another World*, A. T. Schofield.
7. *What is the Fourth Dimension? Reflections inspired by a pair of Gloves*, C. W. R. Hooker.

CHAPTER VIII *

Space and Time: Finite or Infinite?

1. Is Our Geometry True?

We may first examine one of our best-known axioms and one of our best-known propositions in geometry: (1) "Two straight lines cannot enclose a space." (2) "The angle-sum of a triangle is equal to two right angles."

(1) Every section of a sphere made by a plane is a circle. If the plane of section passes through the centre of the sphere, the section is a *great circle* of the sphere. All other circles are called *small* circles. The plane of a great circle obviously divides the sphere into two equal parts. The earth's equator and meridians of longitude are examples of great circles; parallels of latitude (as they are conveniently, though not accurately, named), of small circles.

As a rule, only one great circle can be drawn through two given points on the surface of a sphere, for its plane must also pass through the centre, and three points not in the same straight line are sufficient to determine a plane completely. If, however, the two given points are at opposite ends of a diameter, the straight line joining them passes through the centre of the sphere, and an infinite number of great circles can be drawn through them; examples are the meridians of longitude.

The *shortest distance* that can be traced on the surface of a sphere between two points on it is *the arc of the great circle* passing through them. It is obviously the shortest of all the

* The reader will find the subject of this chapter dealt with at greater length in the author's *Science and Theology*

circular arcs that can be drawn between them, and is the one which most nearly approaches a straight line. All the other circular arcs are parts of small circles. The shortest arc is that which belongs to the circle of greatest radius, and the circle of greatest radius which can be drawn on a sphere is the great circle. If a string be stretched between two points on the surface of a sphere (or on any surface) it will evidently be the shortest distance that can be traced on the surface between the points, since by pulling the ends of the string its length between the points will be shortened as much as the surface will permit; thus the string must lie on a great circle.

A line so drawn upon a surface as to coincide with the position of a string stretched across the surface between any two points on the line is called a *geodesic* line. The geodesic line is therefore the shortest line between any two points on the surface. In a plane, a geodesic line is the straight line joining two given points. On a sphere it is part of the great circle passing through the two given points. Although it is true that in a plane two geodesic lines cannot enclose a space, it is not true in the case of a sphere, for any two great circles must intersect each other.

But we live on the surface of a sphere. The best example of a plane that we have is the surface of still water, but, even so, it is only approximately plane, for it partakes of the general curvature of the earth. That the earth is a sphere is an incontrovertible fact, and its sphericity may be verified in all sorts of simple ways. For instance, if into the bed of a straight canal where the water is almost motionless we drive three poles at, say, successive distances of a mile, arrange for the vertical portions above the water surface to be equal, and then take a telescopic sight from the top of the first to the top of the third, the line of vision will pass well below the top of the second, showing that the water surface is not plane but curved. The " hump " of water is clearly visible from one end of the Corinth Canal, the Greek atmosphere being much clearer than ours, and yet if the surface be tested by, say, a spirit level at any part of its length it will be adjudged

plane. The truest planes which human ingenuity can produce are not, strictly speaking, planes at all; they are small portions of the surface of a sphere some 8000 miles in diameter. That they are *very nearly* planes does not affect the argument. That they are not *real* planes is sober fact. If a canal engineer neglected the earth's sphericity and made the bed of his canal absolutely "level", the trench would become less and less deep: it would be like the chord of a circle.

Hence in geometry, since the straightest lines we can draw are not really lines on a plane but lines on a spherical surface, the lines are parts of great circles on a sphere. Hence if we draw two "straight" lines to form an angle, those lines would, if produced to the other "side" of the earth (i.e. in our case to our Antipodes), meet again. Thus the axiom "two straight lines cannot enclose a space" is simply not true.

(2) Any great circle divides the sphere into two hemispheres. If a second great circle intersects the first, the surface of each hemisphere is divided into two *lunes*, and that of the whole sphere into four lunes. A lune is thus the portion of the surface of a sphere bounded by the halves of two intersecting great circles. If a third circle intersects the other two, each of the four lunes is divided into two *spherical triangles*, and the whole surface of the sphere into eight spherical triangles. A spherical triangle is thus the portion of the surface of a sphere bounded by the arcs of three great circles. If the three great circles cut one another at right angles, like the equator and the meridians 0° and 90°, all eight triangles are alike, and all the sides of all of them are equal to quadrants. In these eight equal triangles it is evident that each angle of each triangle is 90°, and that the angle-sum of each triangle is equal to *three* right angles. This is easily verified from an ordinary orange: first cut it exactly into two halves, then into four "quarters", then into eight quadrants; the angles of the quadrants are obviously all right angles. If, however, a smaller triangle than a quadrant is cut, the triangle will be still spherical, but its angle-sum

will now be *less than three* right angles but will be *more than two*. In short, *in every spherical triangle the angle-sum is always greater than two right angles*.

Of course, the larger the sphere the " flatter " the surface, that is, the more nearly does the surface in the neighbourhood of a particular place approach a plane. But even in the case of a sphere with a radius of a million miles the angle-sum of any triangle on its surface is bound to be greater than two right angles. And since we live on the surface of a sphere, every triangle we draw must be drawn on a spherical and not on a plane surface, and our selected proposition " the angle-sum of a triangle is equal to two right angles " is simply not true.

It is quite true that we cannot prove this by actual measurements. The largest triangle we can draw on paper is so very nearly a plane triangle that its angle-sum *approximates* two right angles so closely that no excess whatever can be detected. Absolutely exact measurements are, however, never possible. For instance, the finest line we can draw has *some* width, but when using it for purposes of measurements we, quite calmly, ignore the width entirely. What else can we do?

2. Large Numbers: Their Significance and their Insignificance

We have already had occasion to refer to large numbers.* It will be remembered that it takes rather less than 10 minutes for light to reach us from the sun, inasmuch as it travels at the rate of 186,000 miles a second, that is, at the rate of 6 billion (6×10^{12}) miles a year. This distance is commonly known as a " light-year ".

The nearest fixed star is the star *Proxima* in the constellation of the Centaur. Its distance is about 24 billion miles, i.e. 4 light-years. In other words, light from that star takes four years to reach us.

* See Chap. IV, final section.

If the earth be represented by a tiny grain of sand $\frac{1}{100}$ of an inch in diameter, the sun will be represented by a sphere 1 inch in diameter 10 feet distant. The star *Proxima* will then be represented by another sphere about 1 inch in diameter but 500 miles distant.

Proxima is the *nearest* star. But the stars in the remoter nebulæ are so distant that their light, travelling at the rate of 186,000 miles a second, takes, not merely four years, but something like 150 million years to reach us. We may assume that 160 million light-years represents, within the powers of our present telescopes, the limit of the visible universe. (When the 200-inch telescope at Mount Wilson is completed, we shall doubtless be able to penetrate space to much vaster distances.) Now 160 million light-years is about a thousand trillion ($=10^{21}$) miles. If we assume this universe to be spherical, its volume is about 10^{64} cubic miles. Imagine this vast sphere filled with very fine dust 1000 particles to the inch, or 1,000,000,000 to the cubic inch. The total number of particles that would fill the sphere is about 10^{87}, a number utterly inconceivable except by trained mathematicians. It is safe to assume that 10^{100} is a number which is so great that it is quite beyond the conception of all but gifted mathematicians. If we wrote down 10^{1000} (that is 1 followed by a thousand noughts) we should write down a number which had no real significance even to them. Let the reader try to realize the significance of even such a modest number as a quadrillion ($=10^{24}$), approaching it stage by stage (10^6, 10^{12}, 10^{18}, 10^{24}). Only by much patient thinking will its full significance be brought home to him.

What is the largest number which can be expressed by means of three nines? Not 999, as the reader may think, but 99^9. Let the reader try to write this down at length. He will most certainly fail. Even $99 = 387,420,489$, so that 99^9 represents a number consisting of nearly 400 million figures. Even to write such a number down, working at the continuous rate of two figures a second for twelve hours a day would take about twelve years! But if we are allowed to use the

mathematician's symbol for "factorial", in appearance like a right angle ($\underline{|\;\;}$), or like a note of exclamation (!), and write $\underline{|9}^{\underline{|9}^{\underline{|9}}}$, a far greater number is obtained. $\underline{|9}$ means the product of all the numbers from 1 to 9, and this is equal to 362880. Hence

$$\left\{\underline{|9}^{\underline{|9}^{\underline{|9}}}\right\} = \left\{362880^{362880^{362880}}\right.$$

He would be a bold mathematician who set about the task of expressing such a number at full length. For instance, consider just the first step, viz. of finding the value of 362880^{362880}. We write down 362880 and multiply it by itself, then the answer by the same multiplier, then that answer again by the same multiplier, and so on until 362879 multiplication sums have been worked, the actual answers doubling in length (or thereabouts) at every step, each requiring about twice as much space on paper as the preceding answer. Thus, if one answer comprises in its length 1000 figures, the next answer will comprise about 2000, the next 4000; and so on. But assuming (rashly!) that this work could be completed within a single lifetime, the *real* task would only then begin. We take that stupendous number, consisting of hundreds of thousands of figures and multiply it by itself, then the answer by the same multiplier, then that answer again by the same multiplier, and so on until again 362879 multiplication sums have been completed. Centuries of continuous work? Yes, thousands of centuries. The number as a *number*, over and above the mere array of figures composing it, is, of course, utterly incomprehensible.

The reader may naturally be inclined to ask why, if such a number is incomprehensible, reference should be made to it here. The reason is that we are about to discuss the nature of infinity, and in some people's minds there is an ineradicable prejudice that if they can form some conception of a stupend-

ously big thing or a stupendously large number, they are well on the way to forming some conception of infinity. The notion is utterly fallacious, even nonsensical. To say that an infinite number is " greater than " any assignable number, or to say that infinite space is " greater than " the greatest cosmos which we can conceive, is to say something which no doubt is literally true, but nevertheless it betrays a half-belief that a very big thing more nearly approximates infinite space than does a very small thing, and that a very big number more nearly approximates an infinite number than does a very small number. It is quite useless to try to think of infinity in terms of *magnitudes*, however great (or however small). To form any such comparison is to misconceive the notion of infinity entirely.

3. The Notion of Infinity: Fallacies and Paradoxes

The famous French mathematician, **Jules Henri Poincaré** * (1854–1912), imagined a world enclosed by a large sphere and subject to the following laws: (1) the temperature is not uniform, but is greatest at the centre and gradually diminishes towards the circumference where it is absolute zero (—270° C.); (2) all bodies in this world have the same coefficient of expansion, so that the linear expansion of any body is proportional to its absolute temperature; (3) a body transported from one point to another is instantaneously in thermal equilibrium with its new environment. Obviously any moving object that approached the inner surface of the sphere would, under such conditions, become smaller and smaller; and, although from the standpoint of ordinary geometry such a sphere-world is finite, its inhabitants could believe it to be *infinite*. For as they approached the surface of the sphere they would become colder and colder and at the same time smaller and smaller; the steps they would

* Not to be confused with his cousin, Raymond Poincaré, the French Prime Minister.

take would therefore be always shorter and shorter, so that they could never reach the sphere boundary.

The reader is probably familiar with a spherical mirror: examples are to be seen in toy shops at Christmas time. Such a mirror reflects all the surrounding objects in miniature. Any given object in front of it is apparently represented by a fixed image behind the mirror. The more distant the object, the nearer is the image to the focal position half-way between the spherical surface and the centre of the sphere, and the smaller does it become. When the object is indefinitely distant, the image is indefinitely near this focal position, and it is indefinitely small; but it can never actually reach the focal position and become infinitely small, for this would mean removing the object to an infinite distance, which is impossible. The image of a man outside, measuring with a rule a straight line normal to the mirror, would contract more and more the farther away the man went, but with a shrunken rule the man in the image would count out exactly the same number of feet as the real man. But no matter how long a line the real man measured, he could never measure more than a finite line, and his image would thus never reach the focal position. The more distant stars might be reflected in the mirror, but their images would never quite reach the focal positions on the surface of the imaginary inner concentric sphere of half the radius of the mirror sphere. The man in the mirror could thus never reach the surface of this focal sphere. He would imagine the space between the two spheres to be infinite in extent, though we know it to be finite.

A common statement in algebra is, "sum to infinity" such a series as 1, $\frac{1}{2}$, $\frac{1}{4}$, &c. But the word "sum" as applied to an infinite series is used in a purely conventional and artificial sense. We cannot deal with such a series as if it consisted of a finite number of terms. An infinite series cannot be "summed".* But we can find a *limit* to which the sum of any number of terms of the series continually

* See Chap. VI, p. 117.

approximates more and more nearly. The limit of the sum of the above series, for instance, is 2, but the sum of even such a number as 10^{100} terms of the series is less than 2.

If we accept the view that a line is composed of points, it is clear that the line cannot be composed of a *finite* number of points; otherwise, if the number happened to be odd, how could the line be bisected? Again, as is well-known, no two whole numbers can express the ratio between the side and the diagonal of a square, but if each of the lines contained a finite number of points there would be a definite numerical ratio. The very existence of such incommensurables proves, in fact, that every *finite* length must, if it consists of points, contain an *infinite* number. In other words, if we were to take away the points one by one we should never take away all the points however long we continued the process. The number of points, therefore, cannot be *counted*, for counting is a process which enumerates things one by one. *The most characteristic property of an infinite collection is that the collection cannot be counted.*

Consider two concentric circles. Take a number of points on the circumference of the outer circle, and from the centre draw a radius to each point. Each radius cuts the circumference of the inner circle, so that there are as many points on the circumference of the inner circle as on the circumference of the outer. Imagine the outer circle to be so large as to extend to the remoter nebulæ, and the smaller one to be so small as to be only just visible to the eye. Further, imagine an indefinitely large number, say 10^{100}, points taken on the circumference of the outer circle, and all the radii drawn; the number of points on the circumference of the inner circle must also be 10^{100}. Evidently there are, in any line, however short, more points than any assignable number.

Is the axiom "the whole is greater than its part" universally true?—"A sheaf of rays emerging from any point in space" is sometimes defined by mathematicians as the infinite "totality" of rays completely filling the space around the point. Let such a point be the centre of two concentric

spheres, one indefinitely large, one indefinitely small. Then, since the number of rays is infinite, and since every ray pierces both spheres, and all the points on the outer sphere are paired with all the points on the inner sphere, the number of points in each case is infinite. Now on the surface of the larger sphere take an area equal to the surface of the smaller sphere. This area contains the same number of points as the surface of the smaller sphere, a number which is equal to the numbers of points in the larger sphere. Thus the number of points in a *part* of the surface of the larger sphere is equal to the number of points in the *whole* of the surface of the larger sphere. We therefore have *a second characteristic of infinite collections*, that *the whole is not greater than its part.* It should be noted that the equality in the above example does not subsist between *areas* but between *point-collections.* Evidently, the axiom "the whole is greater than its part" cannot be universally true; it is certainly invalid in the world of infinities.

If we are given an infinite collection of things, any finite number of the things can be added or taken away without increasing or diminishing the number in the collection. Even an infinite number of things may, under certain conditions, be added to or taken away, and an infinite number still left. For instance, imagine the infinite series of natural numbers, 1, 2, 3, &c., written down in a row, and the even numbers, 2, 4, 6, &c., written immediately underneath them:

1	2	3	4	5	6	7	8	. . .
2	4	6	8	10	12	14	16	. . .

so that under each number in the top row stands its double in the bottom row. Then the number of numbers in the two rows is the same, yet the second row results from taking away all the odd numbers (themselves an infinite collection) from the top row. Thus the number of all finite numbers is not greater than either the number of all even finite numbers or the number of all odd finite numbers. Again, therefore,

we have an instance of a whole being not greater than its part.

Was Tristram Shandy a mathematician or an historian? We are told that he undertook to write a history of the world, and it took him a year to write up the events of a day. Obviously if he lived for only a finite number of years, the older he became the farther away he would be from finishing his task. If, however, he lived for ever, no part of the history would remain unwritten. For instance, events of the hundredth day would be written in the hundredth year, of the millionth day in the millionth year, of the *n*th day in the *n*th year. Hence the events of *any* assigned day would be written about, and therefore no part of the history would remain unwritten. Since there is a one-to-one correlation between the times of happening and the times of writing, and the former are part of the latter, the whole and part have the same number of terms. In infinite time the number of days is no greater than the number of years. In ordinary life, it is true, the identity of whole and part is impossible, but the supposition that it is therefore always impossible is the result of an illegitimate induction—unless at least we pronounce infinity to have no meaning.

If geometrical points are real, between any two points in a line there must be an infinite number of other points. A common mathematical series will help to make this clear. Consider any number of fractions less than 1 arranged in order of magnitude. Between any two of these there are possible others, for instance the arithmetical mean of the two. Thus between any two, however little they differ, there is an infinite number of other fractions. *Consecutive* fractions (that is, fractions between which, for instance, a mean cannot be inserted) are inconceivable; so also are consecutive points in space or, if instants are real, consecutive instants in time. Between any two points, there must be an infinite number of other points, and between any two instants an infinite number of other instants. A space may be halved and halved again, and so on indefinitely, and at any stage of the process the parts are still spaces, not points. In order to reach points

by such a method, it would be necessary to come to the end of an unending process, which is impossible.

Zeno (495–435 B.C.), like his master Parmenides, was a member of the Greek Eleatic mathematical School, and was famous for the difficulties he raised in connexion with questions that required the use of infinite series, of which his paradox of Achilles and the tortoise is the best known. He argued that the swift-footed Achilles could never overtake the tortoise, since, before he could overtake it, he must first reach the place from which the tortoise started; by that time the tortoise will have got some way ahead. Achilles must then make up that, and again the tortoise will be ahead; and so on, without end. The argument assumes that the halving process may go on for ever, and so presupposes that space is infinitely divisible, or already consists of an infinite number of points. The assumption is perhaps legitimate. But it is further assumed that an indivisible moment of time is required for the transition from one point of space to another, and thus it is concluded that an infinite number of moments must elapse before any space whatever is got over, since any space contains an infinite number of points. If we admit this premiss, the conclusion is quite correct; but the assumption that an infinite number of instants make up an infinitely long time is entirely unjustified, and therefore the conclusion that Achilles will never overtake the tortoise does not follow. An instant does not last for a finite time; there is no beginning and end to an instant, with an interval between them. As Zeno's argument is obviously invalid, we are forced to conclude either that the number of points in any finite space and the number of instants in any finite time is infinite, or that space and time do not consist of points and instants at all.

The reader must decide for himself which of the two alternative hypotheses he can accept. Points and instants, which are regarded by mathematicians as a convenient fiction, are both *logically* possible and are consistent with the facts of experience, but there is no conceivable evidence for or

against them. We cannot with our senses discriminate between objects which, though really different, *look* exactly alike and are indistinguishable, and it is impossible to decide between different hypotheses which differ only as to what is below the margin of sense discrimination. Two sense data may be, and must sometimes be, really different even when we cannot perceive any difference between them, and we are not justified in assuming that sense data of a given kind really form an unbroken and continuous series. That space and time are continuous, that the number of shades in the spectrum is infinite, and so on, are unverifiable hypotheses, possible logically, perfectly consistent with known facts, simpler than any other tenable hypothesis, but not the only hypotheses.

The terms finite and infinite are mutually exclusive and correlative. We think of a line as finite in length, that is, as finishing here or there; or we try to think of it as infinite in length, that is, as unfinishing, finishing nowhere, extending without limit. Such expressions as "extending both ways *to* infinity", "*at* an infinite distance", are mathematically convenient, but they have no correspondence with reality.

Etymologically, the term infinite is somewhat misleading. The term signifies, literally, "having no end", but some infinite series have ends, some have not. The series of instants from any earlier one to any later one, is infinite but has two ends. Fundamentally, the notion of infinity seems to be involved in the properties of certain *classes*. A class which is infinite is, by its defining concept, given all at once, and cannot be reached by successive enumeration. Thus an infinite set of points can be given all at once as making up a line or area or volume, though points can never be reached by the process of successive division.

Euclid defined a point as that which has neither parts nor magnitude. But how can such a definition have any positive meaning or any significant connotation? Modern geometers do not attempt to define a point at all. Clearly we cannot reduce it to an absolute nothing, for an infinity of

nothings is still nothing. It is best looked upon as a convenient term for whatever entity may be found by intuition and trial to satisfy the hypotheses we feel compelled to form when considering the nature of the infinite. The reader must carry in his mind any image of a point that he can reconcile with what is said about it. A line may be defined as a "class" of points, but the geometrical element called point seems to be undefinable.

We cannot form any conception of the infinite by addition or multiplication, for this cannot give the unlimited; nor by generalization, for generalization only groups things by means of their known qualities, and unless we have infinity in the individual things, we cannot have it in the group; nor by any process of reasoning, for unless the infinite is in the premisses, it cannot find a place in the conclusion. True, the mind is driven to believe that there must be something beyond its widest concept, but the actual imagining power of the mind can never go beyond an expansion with a boundary. The mental picture is that of the very large or the very long, but still the finite. No sort of clear conception is possible when we speak of infinite space, infinite time, infinite force, or infinite power. Both the infinitely great and the infinitely small are unimaginable, inconceivable, and incomprehensible. We are certain that an infinite reality can never be *perceived.* Infinity must always be *merely* a necessity of thought. How can it be anything more? *

4. Do Parallel Lines Meet?

Take in a plane an unlimited straight line p (fig. 43), a point S not in the line, and a line q drawn through S and intersecting p in the point A. Let the line q rotate about S, as indicated by q_1, q_2, q_3, q_4, q_5. The point of intersection A

* For a more detailed exposition of the subject of this section, see Bertrand Russell's *Lowell Lectures*, delivered at Boston, U.S.A., in 1914, published as *Our Knowledge of the External World.*

will move along the line p to the right (A_1, A_2, A_3, &c.) until it is lost to view, then will appear to the far left, moving along the line in the same sense as before. Mathematicians make the conventional assumption that the two lines p and q have not at any time ceased to intersect, and that the point A has moved continuously along the line p, disappearing at the far right and reappearing at the far left *immediately* after

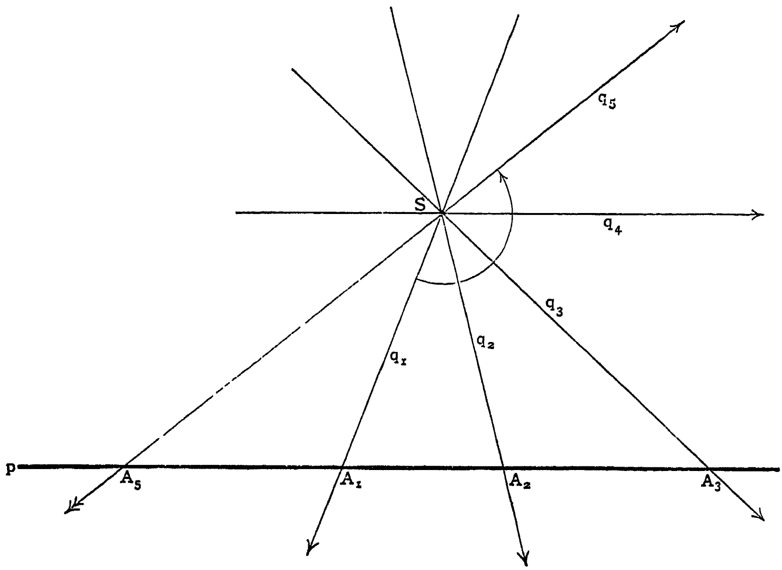

Fig 43

passing through but a single position which lies outside the accessible region of the plane.

There is one intermediate position q_4, where q does not cut p, and that is where q is parallel to p. In every other position it cuts p in some finite point. It is customary to say that in the parallel position, q_4, q cuts p in A at an *infinite* distance, and that though q does not then cut p in any *finite* point, yet q and p meet at infinity.—This is just a useful mathematical fiction.

But it must never be forgotten that points at infinity are

purely imaginary. The geometrical results which are based on the assumption that such points exist are true for that finite region of space which is within our reach; beyond that region the results may or may not be true—we do not know.

5. Euclid's Parallel Postulate

If a straight line meets two straight lines in such a way as to make the two interior angles on one side of it together less than two right angles, these straight lines will meet on that side if continually produced.

This so-called twelfth "axiom" of Euclid is more correctly described as a "postulate", for it involves an unproved assumption.

Euclid's statement of this parallel postulate obviously lacks the simplicity and intelligibility which ought to characterize a fundamental proposition. This objection cannot be urged against Playfair's version: *through a point not in a given straight line, there cannot be drawn in the same plane with it more than one straight line that does not cut it.* But though the phrasing is simpler, the proposition is precisely the same, as all mathematicians readily recognize.

The postulate admits of definite rejection, and a rigorously logical and independent geometry may be developed on the assumption that *more than one* straight line through the point (Playfair's version) is parallel to a given straight line. This geometry gives results empirically undistinguishable, within the limits of observation, from those of Euclid.

It was after innumerable vain attempts to prove the truth of the postulate that non-Euclidean geometries were thought out. They are essentially different from Euclid's geometry, and they follow from *a denial of the truth of the parallel postulate.*

But it is first necessary to consider the nature of an axiom.

6. The Nature of Geometrical Axioms

Geometry has sometimes been defined as the "science of space", but such a definition is open to criticism. If space is infinite, it cannot be measurable. *Things* in space can be measured, but, when the things are removed, the space they first occupied cannot be measured, for, although such space is finite, its boundaries are now lost. To say that geometry is the science of space is something like saying it is the science of emptiness or even of nothingness. It is more correct to say that it is the science which deals with the sizes, shapes, and distances of things. We perceive the shapes of bodies by means of the senses of sight and touch and the muscular sense, but as we have no recollection of the long laborious process of the manner in which we learned to perceive, the actual origin of much of our geometrical experience is lost and unknown to us. Such past geometrical experiences as we can remember are usually an inextricable medley of facts, and inferences more or less doubtful; and it is difficult to reduce them to order.

When we define a thing, we define it in terms of something else, this in terms of again something else, and so on. Evidently some term or terms must be left undefined, and thus in a rigorous treatise on geometry we find no definitions of such terms as *point*, *straight line*, and *between*, the very terms which a layman might think it easiest to define. Again, when we prove a proposition in geometry, we prove it by reference to some already proved proposition, so that at least one proposition must be left undemonstrated. When for purposes of instruction accumulated geometrical knowledge was first systematized, the simplest principles, those apparently free from doubt and contradiction, were placed at the beginning. These principles were reduced to a minimum, and gradually they came to be regarded as higher truths

than demonstrated truths, and their empirical origin was not unfrequently forgotten.

Axioms cannot be *a priori* truths or necessities of thought, for they would then impose themselves upon us with so overwhelming an authority that we could not conceive their contradictories, or on these found different systems of geometry. Nor, strictly, are they generalizations from experience. They are rather *abstractions* from experience, but somehow in the process of abstraction an assumption is made and becomes involved in it. That, ultimately, they repose on experience there is no doubt whatever, and since this experience is limited to a finite region and usually a very small finite region, there is a danger in asserting that the axiom holds universally. The certainty which we attribute to generalizations of empirical science, for instance the laws of chemical combination, arise from our finding no exception to them, and it is true that, within the small finite region of space with which we are familiar, we find no exception to the axioms; but it does not by any means follow that we can legitimately extend the generalization to all space. The axioms are the result less of generalization than of idealization of our spatial experiences. It is true that the choice of the concepts is suggested by the choice of facts, but the choice remains free.

Since the axioms are not necessary truths, and since those we use are entirely a matter of choice, it follows that there is a possibility of displacing them by others. Geometry being purely deductive, the choice of premisses is a matter of indifference. Some mathematicians say that axioms are nothing but definitions in disguise, others that definitions are nothing but axioms in disguise. The reader can take his choice.

It is exceedingly difficult—it is probably impossible—to pick out from geometry a list of unassailable axioms, and in any case they are to be regarded not as self-evident but as unproved. Primitive ideas are explained by means of descriptions intended to point out what is meant: but since

the explanations really involve the ideas they explain, they cannot be said to constitute definitions.

7. The Origin of non-Euclidean Geometry. Lobatchewsky and Riemann

Increasing doubt concerning the truth of some of Euclid's axioms gradually led to increasing certainty that different systems of geometry, each internally consistent but inconsistent in many respects with each other and with Euclidean geometry, could be developed. Non-Euclidean geometry seems really to have originated at Göttingen, where the well-known German mathematician **Gauss** (1777–1855) saw that Euclid's parallel postulate was possibly, if not probably, false, but Lobatchewsky and the two Bolyais went further and boldly assumed that the postulate really was false.

The leader of the movement was the Russian, **N. I. Lobatchewsky** (1793–1856), a Professor of Mathematics at Kazan, and he was the first to publish a non-Euclidean geometry. **Bolyai** *père* (1776–1856) was an eccentric Hungarian teacher who at his own request was buried under an apple tree, to commemorate the three apples which, he said, had so profoundly affected the history of the human race, those of Eve, Paris, and Newton. (His authority for stating that the first-named was concerned with an apple is not stated.) **Bolyai** *fils* (1802–60) was an able mathematician and a talented musician, but he was by profession a soldier, well known for his fiery temper. In one of his quarrels he accepted the challenge of thirteen brother officers, on the condition that, after each duel, he might play a waltz on his violin. He is said to have vanquished them all, and to have played the thirteen waltzes perfectly.

Euclid's parallel postulate states, in effect, that the two straight lines p and q (where p is of unlimited length and q rotates about a fixed point S) have not at any time ceased to

intersect, that the point A has moved continuously along the line p, disappearing at the far right and reappearing at the far left *immediately afterwards*, and that there is only one position in which the lines do not intersect, viz. when p and q are parallel (fig. 44). But Lobatchewsky argued that there must be a finite angle through which q must be turned, after A had disappeared at the far right, before it could reappear at the far left. Let q_1 be perpendicular to p and let

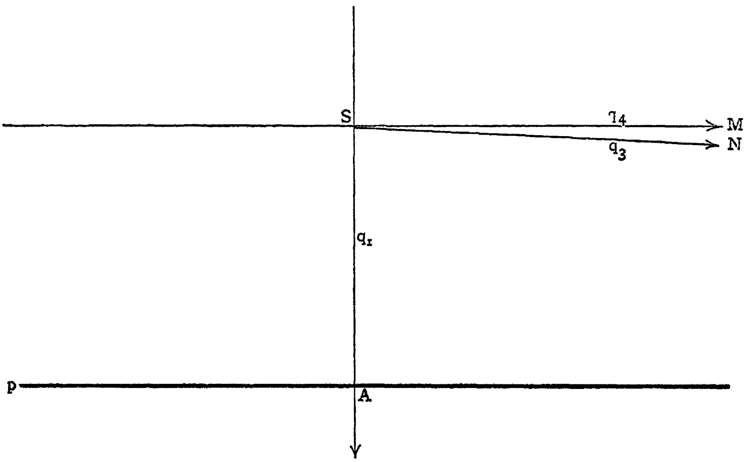

Fig. 44

ASM be a right angle. Then the two hypotheses are: (1) as **Euclid** affirms, every straight line q through S which falls within the right angle ASM will cut p; (2) as **Lobatchewsky** affirms, only those straight lines through S which fall within the acute angle ASN (of uncertain magnitude) will cut p, the straight line q_3 to the right of q_1 being the limit between those lines which cut p and those which do not. Similarly to the left of q_1. Of course the angle ASN can in any case be only very slightly less than a right angle, for, if it were not, a slight prolongation of q_3 would bring about an obvious intersection with p. (The true perspective is necessarily distorted in any possible figure, for the supposed actual variation

from a right angle cannot be within the range of sense perception.) Lobatchewsky admitted, of course, that, within the limits of any measurable plane, Euclid's conclusion must be correct, but he denied our right to extend that conclusion beyond such limits, and that is what we do if we accept the parallel postulate. He maintained that, for all positions between SM and some other line SN, there was no intersection with *p*. It therefore follows that, no matter how small the angle MSN may be, an infinite number of parallels to *p* may be drawn through S. And from this it follows directly that *the sum of the angles of a triangle is less than two right angles.*

Lobatchewsky retained all Euclid's axioms except the parallel postulate, but his theorems are very different from Euclid's. Yet his geometry is as rigorously logical as Euclid's. The many differences are the direct consequence of the non-acceptance of the parallel postulate.

A little later, **G. F. B. Riemann** (1826–66), a German mathematician, discovered that there was another of Euclid's axioms that ought not to be accepted, viz. the tenth: "two straight lines cannot enclose a space", or "two straight lines cannot intersect twice". A denial of this axiom is, as we have already seen, logically necessary if the surface which is commonly called *plane* is considered to be *spherical*, as is actually the case with all planes, so-called, on the earth's surface. Since all "straight" lines are then parts of great circles, they should be called "shortest" or geodesic, and they will all intersect twice; on such a surface there can be no parallels; and in any triangle the *angle-sum must be greater than two right angles.* Thus Riemann's geometry gives us a third system, though it is really equivalent to spherical geometry.

The fundamental distinctions are easily seen. In **Euclid's** geometry there is only one parallel, and the angle-sum of a triangle is *equal to* two right angles; in **Lobatchewsky's**, there is an infinite number of parallels and the angle-sum is *less than* two right angles; in **Riemann's**, there are no

parallels, and the angle-sum is *greater than* two right angles.

Lobatchewsky's real intention is, in point of fact, open to some doubt. If, as seems possible, he meant his system to apply to the Euclidean surface, then Lobatchewsky's geometry only contradicts the parallel postulate, and is merely an alternative system to Euclid's geometry. But if he intended his system to apply to *some other surface* than that which Euclid calls plane, then he does not contradict Euclid, and he does not establish a different system of geometry, but he gives us a geometry of a *pseudo-spherical surface*, that is, *a surface of constant negative curvature.* Whether this was his intention or not, his plane geometry (as we call it) was shown by E. Beltrami, an Italian mathematician, to be identical with the geometry of a pseudo-spherical surface. Similarly, Riemann's geometry is identical with that of *a surface of constant positive curvature*, for example a sphere. The whole question thus assumes an entirely different aspect when it is stated that the three geometries concern different types of surface, and not the same Euclidean plane surface. But more than this: Riemann extended the notion of measure of curvature from surface to *space*. He gives proofs to show that observation cannot establish the fact that space is strictly Euclidean, and he demonstrates that there is a possibility of space being finite, though, like Euclidean space, unbounded; in such a space every "straight" line would return into itself and be closed.

8. Different Surfaces of Constant Curvature

Every system of geometry is founded on the assumption that any given fixed geometrical figure may, without changing its form, be transferred from one part of space to another. This axiom of *free mobility* was made use of by Euclid, though not formulated by him. Now, although it seems obviously possible, within the limits of a plane, to take a plane figure, for instance a triangle, out of one position of the plane and bring it into another, without altering its sides

and angles, can this be done on other surfaces? The test is easily made by the use of some flexible and inextensible material like paper, from which may be cut, say, a triangle, and applied to the surface in question. Such a triangle can be applied to the surface of a cone or cylinder, and although there will be a bending of the figure there will be no stretching or contracting, and the figure will touch the surface at every point, no matter to what part * it is applied. It can be made to slide about the surface which it will closely fit all the time, just as if the surface were plane. During any bending that may be necessary, lengths and angles remain constant. Just as a plane surface has no curvature, so with the surfaces of a cone and cylinder: all are said to have a "zero" curvature.

It is obvious that a plane triangle could not be similarly applied to the surface of a sphere. Without crumpling, the triangle could not be made to touch at more than one point. But if we imagine a triangle drawn on the surface of a sphere, and then lifted and placed on any other part of the sphere, it would fit exactly, and could be made to slide freely over the whole spherical surface. The curved surface of an egg evidently does not possess this property; no closely fitting figure could be made to slide over the whole of it.

When a surface like that of a plane or a sphere admits of a figure sliding over it in close contact all the time, the surface possesses certain special properties, and its "measure of curvature" is constant. In the case of a plane, the measure of curvature is *zero*, in the case of a sphere it is *positive*. The smaller the radius of the sphere the greater its measure of curvature.

But there is a third kind of surface, that of the pseudosphere, the geometry of which is similar to that of the plane except that the parallel postulate does not hold good. The surface is not easy to describe, for at every point it exhibits, in directions proceeding from the same side, a partly concave

* The conical and cylindrical *bases* form no part of the conical and cylindrical surfaces proper

and a partly convex character, something like the mid-point of the surface of a saddle, or of the top of a mountain pass, or a point on the smallest circumference inside a hollow ring.

The radii of curvature at such a point have opposite signs, and the measure of curvature is therefore *negative*. As in the case of the plane and the sphere the measure of curvature is constant. Thus we see that in the three cases of the plane, the sphere, and the pseudosphere a figure that fits in one place may be moved about freely in all directions without any change in the length of its lines or in the magnitude of its angles. But only in the case of the plane is the postulate of *similarity* applicable, for this postulate requires the possible construction of a figure, on any scale, similar to a given figure, and in practice this really depends upon the ordinary doctrine of parallels. Euclid's geometry is the geometry of the plane; Riemann's is identical with that of the sphere; and Beltrami has shown that Lobatchewsky's is identical with that of the pseudosphere.

According to Riemann, just as the two-dimensional surface of a sphere is unbounded but finite, and just as that surface may be regarded as a two-dimensional space, so we may by analogy assume the existence of a three-dimensional finite unbounded space of constant positive curvature. Our own world space would thus be conceived to be *finite*, not infinite, though *unbounded*. Just as figures drawn upon surfaces of constant curvature, whether zero, positive, or negative, can be displaced, without distortion, on those respective surfaces, so should analogous conditions, according to Riemann, hold for rigid bodies, which therefore would be capable of free motion only in a space of constant curvature. Just as all lines on a sphere are of definite finite length, closed and returning into themselves, so Riemann conceived in his three-dimensional space of positive curvature, analogues of the straight line and the plane, *finite* but *unbounded*. Is this an illusion? The possibility of the ordinary three-dimensional space of experience being curved and, as a consequence, finite, is the very core of Riemann's theory.

9. Riemann's Notion of Finite Space: its Obscurity

It is fairly safe to assume that, within the portion of the space of experience of which we are cognisant, space has the special property that a given body can be transferred from any one point to any other, without suffering in the transference any distortion, whether distension or contraction. The space of experience has therefore a constant measure of curvature. But it does not follow that this applies to *all* space, for we certainly have no right to dogmatize concerning the unknown. There is, moreover, the further assumption that space is homaloidal,* in other words, that its constant measure of curvature is equal to zero: the assumption appears in Euclidean geometry under the guise of the parallel postulate. But it is clearly impossible to be cognisant of the parallel lines contemplated in that postulate. All we really know is that the limited portion of space that falls within our experience is practically homaloidal. *If* space has a constant measure of curvature and *if* it is homaloidal, it must be infinite.

But if the measure of curvature is *positive*, the premisses not of Euclid's but of Riemann's geometry follow, and then space must be *finite*, that is, the extent of space must be limited to a finite number of cubic miles. For, in that case, no matter how slight might be the difference of the curvature constant from zero, any point which moved continously onward in a "straight" line (more accurately, in a shortest line or a geodesic) would ultimately, though perhaps after having traversed a distance to which 10^{100} light-years is an insignificant trifle, arrive from the opposite direction at the place from which it set out. If the point had started upwards, it would return from below. The notion seems incredible, but so, too, to primitive man would the notion have been that, if we start round the world to the west and keep on

* Greek, ὁμαλός, even, level. In geometry, flat, uncurved, everywhere the same.

in the same direction, it would be from the east that we should return to the starting-point. If, then, the space constant is positive, space must in some way return into itself. Its volume must be finite, just as the surface of a sphere is finite. But although the conception of a straight line regarded as a shortest line or geodesic, and therefore finite and returning into itself, is simple, for we get it on the surface of a sphere, does the statement, *space* is finite and returns into itself, lead to any clear conception? *Can we conceive a three-dimensional analogue to the surface of a sphere?—We cannot.* But then we cannot form an adequate conception of the aether, of the origin of consciousness, of the nature of life, of the soul, of the First Cause, of a hundred other things. Absolutely to refuse to believe merely because we cannot adequately conceive, may certainly be a little rash. If a reasonable man be really rational, how dare he be pontifical? Evidence is often very scrappy, even shadowy, nevertheless it may have a cumulative force which peremptorily forbids a positive denial.

10. Can Riemann's Space-curvature be Tested Practically?

Apparently the question could be definitely settled if we could actually measure the curvature-constant, and the only possible means of doing this seems to be by astronomical observation, that is, by measuring the vast stellar triangles of parallax investigation and finding out whether the angle-sum is equal to or greater than two right angles. Such triangles of this kind as have been measured certainly do tend to confirm Euclidean geometry, and with an accuracy which is really remarkable. In no case has the angle-sum differed from two right angles by as much as the one-hundredth part of a second, i.e. $\frac{1}{360000}$ of a degree. But these triangles, though based on distances of billions of miles, are utterly insignificant when compared with the dimensions of space

itself. Viewed in its true relation to space itself the whole of the visible universe must presumably be an inconceivably small microcosm. Our means of measurement are therefore utterly inadequate to enable us to pronounce authoritatively on the presence or absence of curvature of space. If the curvature *is* zero, space must be flat, homaloidal, Euclidean.

But the same problem involves other difficulties. The application of Euclidean geometry to astronomical mensuration assumes that light is propagated in lines which are straight in the Euclidean sense. A body which emits light creates a disturbance which is propagated outwards in all directions through the æther. The disturbance reaches points equidistant from the body at the same time. Neglecting corrections for aberration and atmospheric refraction, the assumption is thus made that the line of vision, which is normal to the advancing disturbance, is in the direction in which the body lies. When in considering the effect of the earth's atmosphere we say that the "rays" are "refracted" or bent, what we really mean is that the wave-front of the disturbance is deformed in its passage through the obstructing atmosphere, so that, in general, the line of vision does not coincide with the direction of the body. Neither the rising sun nor the setting sun, for instance, is seen in the direction in which it really lies.

Suppose, then, that stellar triangles with an angle-sum greater than two right angles are some day discovered. The Euclidean would attribute the curvature of the triangle to some physical cause, perhaps to refraction of the aether, at all events to some unknown obstruction to the uniform propagation of light. The non-Euclidean would argue that the cause is not necessarily physical, that the result is perfectly consistent with the uniform propagation of light, that the directions of vision do coincide with the directions of the star from the observer, but that the lines of direction are not straight in the Euclidean sense: they are the "straight" lines (more properly geodesic lines) of Riemann's geometry, which return into themselves. Hence if such stellar triangles are

discovered, we shall have to abandon either Euclidean geometry or the hypothesis that the propagation of light is rectilinear.

Different kinds of space appear to be conceivable, but the co-existence of different kinds of space is not. The absolute independence of the one we adopt is a logical necessity; so also are its properties. Hence if in order to render intelligible the supposed conception of a non-Euclidean space we import into it some characteristic feature of Euclidean space, this logical condition is violated. For each conception of space must involve a notion of direction peculiar to itself, just as each of these conceptions involves a space-constant or specific measurement peculiar to itself.

Since it is impossible to give to ordinary notions of direction a place in the conception of non-Euclidean space, and since it is difficult to avoid introducing such ordinary notions into any spatial conception we may form, it is doubtful if after all we are justified in saying that different kinds of space are conceivable. Certainly it seems to be quite impossible to form any clear conception of a space in which a shortest line would not be a straight line. Yet this does not mean that we may question the logical integrity of either of the non-Euclidean geometries. They are on precisely the same footing as Euclid. But whether any one of the three geometries, and, if so, which, has an external validity as an exact description of perceptual space, it is at present impossible to say.

There is a widespread fallacy that the possibility of the geometry of three-dimensional space being other than Euclidean depends on the physical existence of space of four or more dimensions. The absurdity of a four-dimensional space was shown in the last chapter.

11. Idealized Euclidean Space: its properties

Untutored and simple-minded people, who, like the astronomers of antiquity, never question their direct percep-

tions, see the heavens approximately as a sphere, finite in extent. But as soon as the mind has acquired the power of forming abstractions, it begins to idealize its space of sense-experience. By untrammelled orientation, by progressive motion in every direction, we invest this space of experience with identical constitution at all places, and we assume that it extends to an infinite distance in all directions. But all that experience makes certain are the correlated spaces of the several senses. Even this single correlated space is only a logical construction and is therefore not necessarily an independent reality. It is particularly desirable, therefore, to guard against looking upon the infinite space which we construct mentally as necessarily a reality.

Phenomenally, space is nothing. Our recognition of it is, in fact, a recognition of absence of response to our senses, the effort to touch or see but the finding of nothing. In the phenomenal universe, space is that which gives us no sentience and offers to us no resistance, so that it does not exist in the manner in which we suppose particular portions of the universe to exist. The non-existence of space cannot by any mental effort be imagined. We cannot get rid of the idea that space surrounds us on all sides. We are compelled to think of it as everywhere present, and we cannot conceive its absence either in the past or in the future. *Since the non-existence of space is inconceivable, its creation is inconceivable.*

The properties of the idealized space of Euclidean geometry, therefore seem to be: (1) it is continuous; (2) it is infinite; (3) it is of three dimensions; (4) it is homogeneous; (5) it is non-resistant; (6) it yields no response to our senses.

Of bodies absolutely at rest, we know nothing. The earth revolves round the sun; the whole solar system is rushing through space, in relation to the Milky Way, at an enormous speed; and it seems probable that the Milky Way itself, and, indeed, the other one hundred thousand million galaxies, are rushing through space in a similar fashion. A celestial body absolutely without motion in space is inconceivable. If space is infinite, all the celestial bodies may

continue to rush through space for an infinite time. There is nothing to distinguish one part of space from another except in its relation to the position of material bodies. We cannot describe the position of a body except by reference to some other body. All our knowledge is essentially relative.

12. Time

In its most primitive form, our idea of time seems to be the recognition of an order of sequence in our states of consciousness. If our memory were perfect, we might be able to refer every event within our own experience to its proper place in a chronological series. But it would be difficult, perhaps impossible, to compare the interval between one pair of events and that between another pair.

We must distinguish between (1) mathematical time or duration and (2) apparent or common time.

Mathematical time, "duration in itself", is considered as progressing constantly and uniformly. It is an abstraction from the mere succession of events which we arrange in order, before and after one another. The pauseless flow is sometimes conceived as a succession of instants, but the mathematical instant itself has no duration, just as the mathematical point has no spatial magnitude. Events of which we are conscious do not last merely for a mathematical instant, but always for some finite time, however short. Impressions on our sense-organs produce sensations which are never strictly instantaneous. Instants are therefore not among the data of experience; they are inferred, and, so far as they are constructed at all, are constructed mentally. Two events may be simultaneous, or one may be earlier and the other later. One event may begin sooner than another, but may continue after the other has begun and therefore be also simultaneous with it. If it persists after the other is over it will also be later than the other. As long as we are concerned with events which last for a finite time, however short, the terms

earlier, simultaneous, and later are quite consistent with one another, but they become entirely inconsistent when we are dealing with something instantaneous.

All dates are determined by events. An *absolute* date cannot be given, for we cannot point to a time itself but only to some event occurring in that time. Experience does not give us times as opposed to events. Like instants, therefore, time itself is merely a mental construction; it is inferred. All that experience gives us are events ordered by the relation of simultaneity and succession. Every experience has a certain duration, it may be for the tenth part of a second, or, of course, for very much longer; the amount is variable and cannot always be determined. Every experience also involves change, and duration and change are sometimes described as the elements of time.

Empty time, a time in which nothing happens, seems to be a false conceptual abstraction which has no place in real experience; it is simply equivalent to the suspension or standstill of time. It involves the assumption that our experienced consciousness is to be conceived as a series of illuminated points, from one to another of which we stride across an interval of darkness. But the experienced consciousness is a moving and continuously changing whole, and it is this continuous movement which constitutes the reality of time. For our measure of time we select some arbitrarily chosen motion, for instance, the angle of the earth's rotation. But all cases of motion which come under our consideration are essentially *relative*, as before stated. Equal times are generally defined as those intervals during which the earth turns through equal angles relative to the "fixed" stars, and any duration of time may then be measured by the angle turned through by the earth during the interval. But since the whole scheme of time measurement ultimately depends upon the testimony of the various heavenly bodies, we may legitimately ask, after duly allowing for all the forces which we know are acting on those bodies, whether the length of the day (or the rate of rotation of the earth) is the

same now as formerly. We are quite sure that it is not the same, for it is now an established fact that the solar year is slowly diminishing in length; and we cannot therefore base our fundamental notions of the measurement of time upon the earth's rotation simply. But the *flow* of mathematical time or duration must be conceived to be unaffected by the speed or slowness of the motions of material things, and the *measurement* of relative, apparent, or common time, based upon the motion of the earth, is merely a scheme for meeting the requirements of man's convenience.

Infinite time cannot be imagined, for to follow the regress of movement to infinity requires an infinite time in which to accomplish it. But infinite time may be adequately conceived as exceeding any assignable limit. In order to conceive an existence before the first moments of time, and to connect that existence as cause with the subsequent temporal succession of effects, we must conceive time itself as non-existent and then commencing to exist. But when we make the effort to conceive time as non-existent, we find it impossible to do so. Time, as the universal condition of human consciousness, clings round the language in which we speak of an existence *before* time. Nor are we more successful when we attempt to conceive an infinite regress of time.

Whatever meaning we attach to the term, "eternity" necessarily has its roots in our time experience. In its ordinary meaning it usually suggests lasting through all time, enduring for infinite time. But an endless progress and regress afflicts the mind with helplessness, and many philosophers therefore insist on the essentially *timeless* nature of reality. But this is an overstatement. Absolute timelessness may more correctly be said to belong to *different kinds of truth*. The *knowledge* of any truth is, of course, an event in time; it is part of the history of some mind. We all feel certain at the moment in which we feel any truth that we have not created it for the first time, but merely recognized it; it was valid before we thought of it, and will continue so without regard to an existence of any kind. The inductively

established laws of the physical sciences, if true at all, are timeless truths.

It will have been gathered, then, that Time is not, as we feel at first tempted to assert, bound up with the permanence of physical motions, by which at present we measure it; rather, it seems to depend upon our consciousness of Change in the wider sense, of which physical motion is but a single example. If, therefore, there were no Change, time would not appear to exist for us, and hence would not appear to exist at all. Apparently, then, we ought to be able to conceive a state of things in which Change is transcended. If this be so, we begin dimly to perceive that the beginning of "time" and the birth of our present universe may have been a coincident transition from unchanging existence into the unrest of change. But all this being granted, the question still arises, How was the unrest initiated?

Space, time, matter, and motion are all ultimately traceable to the same experience, namely, to the muscular and visual sensations. It is true that we try to form a separate conception of each, but have we any right to assume that separate concepts stand for possibly separate existences? The results of mental analysis are not necessarily independent factors of creation. Is there any reason to suppose that either space, or time, or matter, or motion ever existed separately? Certainly we have never experienced them separately, and we deceive ourselves if we think that they can be separately explained. When we talk of *motion* we really mean *matter* traversing *space* in *time*. The four seem to be inseparable.

13. Einstein's Space-time

The Englishman, **Sir Isaac Newton,** will always be regarded as one of the world's greatest men, but the work he did is not always accurately gauged. He was not the first to conceive the exact relations between inertia and force; of these, the great Italian, **Galileo,** certainly had an inkling.

The German **Kepler** had, long before, also had a suspicion of universal gravitation. And the Englishman, **Hooke,** had suggested the possibility of the inverse square law before Newton's *Principia* was written. The outstanding feature of Newton's work was that it drew together so many loose threads. It unified phenomena so diverse as (1) the planetary motions that had been exactly described by Kepler; (2) the everyday facts of falling bodies; (3) the rise and fall of the tides; (4) the wobbling motion of the earth's axis; (5) many minor irregularities in linear and planetary motions. With all these drawn into such a simple scheme as the three laws of motion combined with the inverse square law, it is no wonder that for a long period scientific speculation almost ceased. The universe seemed simple, and its main problems solved. During the next century there seemed little to do but develop Newton's dynamics formally. In short, Newton was faithfully followed until little more than a generation ago. Then came the clash between (1) the phenomena of aberration, and (2) the Michelson-Morley experiment. The obvious inference from (1) was that *the aether is stationary*, and is therefore a possible reference frame for all measurements; but the equally obvious inference from (2) was that *the aether is not stationary*. Nobody felt satisfied with the one serious attempt that had been made to reconcile such contradictory inferences, viz. by means of the Fitzgerald-Lorentz contraction hypothesis. The German mathematician, **Albert Einstein** (*b.* 1879), in particular, disliked the idea of a *physical* contraction, and he set to work to devise a more acceptable explanation. Eventually, Einstein showed clearly that we may logically regard the contraction as a *subjective* contraction, depending on the transformations of our space-and-time reference frame.

We have spent our lives in making measurements and calculations in accordance with classical principles with which all our physical concepts are in harmony. We naturally shrink from questioning these principles, much as we should shrink from questioning the multiplication table. And yet

these principles cover merely *old* experience. Why should there not be *new* experience, which refuses to square with the old principles? Clearly there is no reason at all. Naturally we tend to feel that if we question principles hitherto universally accepted, we are acting contrary to common sense. On reflection it will be admitted that this is prejudice. Much of the work in physics during the last twenty years seems to be in flat contradiction to common sense, if by "common sense" we mean old experience. To this extent all great discoveries have contradicted previous common sense. The early scepticism shown towards Einstein is as easily understood as the violent hostility that was shown towards Copernicus.

A "framework" of space and time is the name given to any *system of reference* to which we appeal when we state, for instance, that an event is 100 miles distant from, and 10 hours later than, another. We may, for example, measure distance from a London railway terminus and time as indicated by the terminus clock when the train starts. But where in the boundless void of space is that railway station, and where in the ever-rolling stream of time is the time indicated by that clock? We instinctively distrust an indefinite *where* and an indefinite *when*, and we demand an exact quantitative system of measuring distances and time intervals. Einstein's first noteworthy pronouncement was that there are an indefinite number of such systems of measuring, exactly on all fours with one another. No one of these can be distinguished as more fundamental than the rest. And yet one of them does present itself to us as being the actual space and time of our experience, and we recoil from the other equivalent frames because they seem to us to be artificial systems in which distance and duration are mixed up in an extraordinary way. This invidious selection is not determined by anything distinctive in the frame; it is determined by something distinctive in *ourselves*, by the fact that we are tied to a particular planet. *Nature* offers us an almost endless choice of frames; *we*—quite naturally—select the one in which we and our petty

terrestrial concerns take the most distinguished position. This almost inevitable geocentric outlook has mischievously persuaded us to insist on this particular terrestrial space-time frame. Einstein's theory has completely exposed the fallacy of our attributing to our terrestrial reckoning of space and time a more than local significance. If, as may be possible in the distant future, our descendants are able to roam about space from planet to planet, they will probably be amused at the difficulty we had in learning to read the Relativity alphabet.

The fallacy of our old notion of *simultaneity* must, in particular, be carefully thought out. Suppose a man to die at the age of eighty, 1000 miles from his birthplace. An inhabitant on a rapidly receding star might report the age to be eighty-one and the distance travelled to be billions of miles. A similar estimate would be made if we on the earth reported a like happening on the receding star. Relatively, the earth and star are receding from each other. Consider the earth and two such stars, all receding from one another, and all reporting the happening of events on the others. What about the attempt to discover absolute simultaneity amongst the reported events then? Or look out of your window on to a busy street. The eye claims to see a hundred events all happening at the same moment. But clearly this is a fallacy. It is not the events that are happening in the instant now that the eye "sees", but the sense-impressions to which earlier events gave rise. All the events had to be reported by light-signals, and these take time. All the events happened before we could see them, and the more distant the event the earlier it happened. *We cannot dissociate time from space.*

But this association in no way tampers with our *local* instants which form the stream of our consciousness. Einstein's theory leaves entirely untouched that time succession of which we have intuitive knowledge. It freely admits the possibility of absolute simultaneity, but it emphatically denies that our *knowledge* of simultaneity can be more than relative.

Although *time* is considered jointly with three-dimensional

space as forming a four-dimensional continuum, the fact must be emphasized that time enters the fundamental space-time mathematical formulæ quite differently from space. Time is not a fourth dimension of space; it is a fourth dimension of a mathematical *continuum*. "Totalities" or "manifolds" of more than three dimensions are, as we saw in the previous chapter, common enough in mathematics, but that does not mean anything of the nature of more than three physical *extensions*, or anything so irrational. Space and time have to be considered together simply because we cannot consider them apart. But space remains three-dimensional, and it is absurd to try to think of it as anything else. As we have seen, the usual method of expressing position and motion algebraically in three-dimensional space is by reference to three linear directions, mutually at right angles, like the edges of a cube that meet in one corner. The observer's point of view is the point where three such lines meet.

For mathematical purposes, a sphere may be spatially mapped out by three diameters mutually at right angles, intersecting at the centre O. Though we cannot use a fourth co-ordinate to represent *time*, we may legitimately help our imagination by adopting some such device as this: imagine a series of spheres always to be moving inwards and contracting towards O with the velocity of light, and then to expand from O with the same velocity, this to take place quite uniformly however O may move in relation to other points of observation, so that the centre of the system of contracting and expanding spheres travels with the observer, and each observer has his own system of spheres. The approaching and contracting spheres contain within them the whole *future*; the receding and expanding spheres contain the *past*. The *present* is the passage of a sphere through O, the observer, when the sphere is concentrated to a point. The conception of a fourth dimension is thus not that of a simple spatial dimension like the other three, but it is intimately associated with time and motion, and the observer's experience of it is

simply the happening of events with the flow of time. Obviously to different observers the impressions of the *present* are not quite the same.—Let the reader beware of giving this illustration a too realistic interpretation. It would be utter folly to try to *visualize* space-time. Conceptually for the physicist the space-time of Relativity has virtually the same meaning as Newton's laws of motion, and curvature the same meaning as Newton's forces. It is merely a change of language, necessitated by the discovery of new facts.

Einstein's gravitation theory not only includes all the results obtained by the use of Newton's inverse square law, but it accounts for various minute deviations from the law, and it predicted effects which have since been confirmed. That these deviations really are minute may be gauged from a typical instance—the respective acceleration values calculated for the planet Mercury: Newton's calculated value was increased by Einstein's gravitation equation to only the extraordinarily small amount of $1/10^8$ of itself. That Newton's calculation of two or three centuries ago should be accurate to one hundred-millionth part is remarkable indeed.

For all *practical* purposes, Newton's laws still hold.

Einstein's theory of Relativity has but a slender empirical basis; it is essentially mathematical, but its successful predictions have tended to silence the critics. No forecast can be made of its future empirical validity, and science will always demand such validity as a final test. But any concept which allows an increasingly comprehensive scheme of natural laws to be expressed completely in mathematical form is necessarily of great physical significance.

14. Conclusion

The ordinary negative definition of infinity, as formulated by mathematicians, is legitimate enough, but it is purely subjective; it makes no reference to reality. The vagueness which inevitably attaches itself to our idea of infinity is in-

dicative of our intellectual limitations; the idea concerns reality only in so far as our thought interprets it.

We must regard the infinity of space as resembling the valid negative conception, and not the invalid positive conception, of infinity. By the infinity of space we need not mean anything more than that we cannot clearly *think* a limit to space, cannot think of any space which is not bounded by spaces. So with time: we can conceive no time which was not preceded by an earlier time. The infinity of space and time can never be given as an actual *fact*. Infinity can never be anything real, never more than an imperfect thought construction.

If we argue from the infinity as constructed in thought to the infinity of the spatially extended universe, we relapse into the illegitimate conception of infinity as something positive and actual. If we say that the universe is infinite in space and time, we are really confessing our inability to think of space and time being exhausted and limited by successive additions of spaces and times. But this tells us absolutely nothing as to whether the real universe is infinite. To infer the infinity of the universe from a mere thought-constructed infinity is to assume a complete agreement between reality and thought, and this assumption is utterly unjustifiable.

That which is infinitely great cannot form a totality or a whole; the notion involves a contradiction in terms. Thus the notion of infinite space conflicts with the conception of the universe as a whole, and the notion of infinite time with that of the universe as a process. All hypotheses of evolution imply that the universe has a beginning in time. A process is necessarily and essentially finite, and limited by the two points between which the process lies. If, then, we wish to assert that the universe has a real history, and that evolution is a fact, we must think of the universe as finite, contained within space and originating during time.

It is difficult to avoid the inference that the energy of any finite part of the universe must be undergoing gradual

dissipation, and would have been entirely dissipated if it had existed infinitely in the past. And as this has not as a matter of fact happened, the conclusion is that the universe, with its store of energy which is now being dissipated, came into being at some definite point in the past. In infinite time a *finite* universe must have gone through all possible changes already and thus have arrived at a condition of equilibrium and a changeless state of existing as contrasted with its actual evolving.

Are space and time infinite or are they finite? It is utterly impossible to say. So far as space is concerned, Riemann's idea of space curvature may, eventually, form a clue to the ultimate solution of the problem. But time is admittedly one-dimensional, and no intelligible hypothesis which would enable us to form a conception of the *beginning* of time has yet been put forward. Yet nothing can be urged in favour of the infinity of time or space except a disability of our imperfect thought. At bottom, it is merely a question of a lack of correspondence between the constitution of our minds and that of the universe. Why should we regard such a conflict as necessarily permanent? Why should not the conflict cease when, in the course of ages, the human mind more closely approaches its evolutionary goal?

At present *we do not know*. Why pretend that we do?

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CHAPTER IX

Science: Certainty or Doubt?

1. Measurement in Science

The mathematical textbooks used by most schoolboys in the seventies and eighties were written by the Senior Wrangler and Senior Smith's Prizeman of 1848, Isaac Todhunter (1820–84), and admirable books they were. Those were not the days of specially skilful teaching: boys were not infrequently left to worry things out for themselves, and amongst Todhunter's various collections of problems there were not a few very hard nuts to crack. We often had to wrestle with Todhunter, and we came to respect him.

It was therefore something of a shock to learn in later years that Todhunter had strongly opposed the provision of laboratories at Cambridge.—" It was so unnecessary for students either themselves to work experiments or to see their teachers work them. All experimental results were well-known to the teachers who were men of the highest character and many of them clergymen of the Church of England. Those results would therefore be carefully described and vouched for. Students to be encouraged to question the unimpeachable authority of their teachers! It was unthinkable."

Whether Todhunter himself had ever worked in a laboratory is very doubtful. His descriptions of experiments in his *Mechanics* and his *Analytical Statics* are very general and are obviously second-hand, and he had probably accepted his facts " on authority ", just as he expected his own students to do. Not improbably he was familiar with Plutarch's

apologetic reference to Archimedes, who had invented numerous mechanical appliances for defending the city of Syracuse against the Romans. Archimedes was the king's cousin and ought not therefore to have soiled his hands, but Plutarch rather grudgingly admitted that at a time of such dire peril it was excusable. There are evidently two good reasons why a gentleman should not work experiments: he would by implication show disrespect for authority, and he would be engaged in manual labour.

The ancient Greeks produced some of the best mathematicians the world has ever known, but their science, apart from observational astronomy, was sorry stuff. Even Plato and his pupil Aristotle, probably the ablest Greeks of all, made the most childish mistakes when dealing with physical science. The main reason is not far to seek: the Greeks disliked experimentation. They kept underlings to do all their manual work but this did not include any sort of work in physical science. They themselves were devoted to wrangling. They dug their science out of their heads. Even their mathematics—it was mainly geometry—had little relation to experiment and measurement. Euclid's scheme of geometry, for instance, was built up on the basis of a number of axioms, a scheme which was considered to be logically perfect and resting on foundations which were unassailable. Little did the Greeks think that most of Euclid's axioms would, 2000 years later, be blown sky-high.

Observation, experiment, and measurement form the very life-blood of modern science. Greek and mediæval apriorism has not, it is true, quite disappeared: perhaps it never will. That in every department of science rival theories survive is a sign of strength rather than of weakness; for men who feel strongly about a pet theory will always be on the hunt for new facts to support it, and new facts is the thing that matters most of all.

The layman is prone to put implicit confidence in scientific measurement; he hears so much about it. But how far is measurement possible? *Exact* measurement is

probably *im*possible. Measure the length of your table: it is "about" 5 feet. Measure it rather more carefully: it is "just about" 4 feet $11\frac{3}{4}$ inches. Measure it still more carefully: it is "very nearly" 4 feet $11\frac{15}{16}$ inches. If the scale you use is divided into tenths of an inch, you can, with practice, gauge lengths to hundredths of an inch. Physicists can measure by eye even to tenths of a millimetre, but that is about as far as they can get. The very marks on a wooden measuring rod or steel tape have a width of their own, and even if the ends of the thing to be measured seem to correspond exactly with the ends of the measuring rod or tape, how can we be sure that the length of the rod or tape is itself exactly what it professes to be? We cannot. We heat an iron rod a foot long, and try to measure its increase in length. How? The schoolboy uses a special screw of fine pitch, say 20 threads to the inch, with a graduated head showing, say, 100 divisions. If the screw is turned right round once, it advances (or retreats) $\frac{1}{20}$ inch; if turned round $\frac{1}{100}$ of a rotation, it advances (or retreats) $\frac{1}{2000}$ inch. Evidently the boy has the means of measuring the increase in length of the heated bar to that very small fraction of an inch. But exactly? No. It is unlikely that the screw-head when finally adjusted will show a correspondence *exactly* with one of the graduations: there is a little bit over to be guessed; it is unlikely that any two boys will screw down the head with *exactly* the same degree of tightness; it is unlikely that the internal and external screw threads fit together *exactly*, i.e. with mathematical accuracy; it is unlikely that the heated bar will be kept *exactly* at a constant temperature; and so on.

Makers have shown extraordinary ingenuity in devising different types of metrical instruments, some of which will measure to a really amazing degree of accuracy. But the results are always *approximations*, and close as these approximations may be, there is always the personal equation to be considered. Two persons measuring the same thing and using the same measuring instruments will almost invariably obtain different results.

The instruments used by Sir Isaac Newton were, of course, relatively crude, and it is astonishing that he could make his celestial measurements so accurately that he was able to work out his gravitational theory. When 200 years later Einstein and his co-workers repeated these measurements, they used instruments of far greater precision and obtained results of greater approximation than Newton had been able to do. Actually, the ultimate difference in the results was minute, but it was sufficient to render necessary some revision of Newton's theory, and a new gravitation law thus came to be formulated.

The first call of science is for *facts*, and it likes the facts to be presented in metrical form though it knows that the measurements made can never be more than approximations. Some of the measurements that have been made, especially of the very great and the very small, tend to astonish the layman and to make him sceptical. But the layman may usually feel assured that although many of the measurements are based on inferential evidence and are estimates rather than direct measurements, they are usually quite acceptable approximations, though they can never be *exact*.

2. Discoveries and Inventions

Discoveries are sometimes the result of accident, sometimes the result of systematic search. A successful invention is often the result of the application and adaptation of some quite simple scientific principle. One of the most successful of the world's inventors was the American Edison (by origin half Dutch, half Scottish); during the course of his career he took out over a thousand patents, but nearly all his inventions originated in new adaptations of well-known fundamental principles of physics and mechanics. The American brothers Wright invented the aeroplane; they knew hardly anything about science but a good deal about engineering, and after some years of experimenting they produced a machine that

would rise from the ground: this was in 1903. They had been gravely told to wait until mathematicians had worked out the principles of flight, but they ignored the mathematicians, persisted with their scheme of trial and error, and eventually met with success. The wonderful efficiency of the present internal-combustion engine is due to numberless improvements of inventors and engineers all over the world. The invention of the turbine is largely due to the Englishman Parsons (son of the third Earl of Rosse) who after a host of trial experiments succeeded in devising a rotary engine based on the simple principle that a jet of steam impinging on a steel blade would tend to force it backwards. To some people an ordinary wireless set is an incomprehensible mystery, and now and then one hears a defender of the literal interpretation of the Biblical miracles urging that present-day miracles are by no means unknown, insisting that the result of turning on the knob of his set is an example. Needless to say, all the secrets of the wireless set, e.g. its action as a wave analyser, and its reproduction of the distant sounds, are known to every intelligent Sixth-Form schoolboy; the whole machine embodies a number of clever adaptations of well-known simple principles of physics. The efficiency of the modern set is due to the ingenuity of successive inventors. At the back of it all, of course, are the discoveries, due to prolonged and systematic research of famous physicists, e.g. Clerk Maxwell, Fleming, and Hertz. Separately, the telephone, the microphone, the valve, and wave transmission, have long been familiar to the world. As an invention a wireless set may be described as ingenious, even wonderful, but it certainly has no claim to be a box of mysteries of celestial origin.

That well-known journalist, Mr. Beverley Nichols, in *The Fool Hath Said* (pp. 153–4) speaks thus:

"Miracles.

"They don't happen.

"Very well. It is A.D. 1936. Before you is a black box. You paid ten guineas for it. You open it and turn a knob.

And suddenly the room is filled with a woman's voice. You don't like the voice. You turn off the wireless.

" Silence.

" Silence, you say? Silence? *Why, the music is still going on!*

" No, it isn't. We've turned off the machine.

" What has that got to do with it? *The music is still going on.*

" We need not continue the argument, which is indeed childishly obvious. And yet, I think that most of us are inclined to forget, when we turn on the wireless, that it is *not* the machine which causes the music. The machine is merely an ear—an intermediary. Of itself the machine is incapable of uttering a single squeak. It is a dumb, silent structure of wood and metal. It can only echo what it hears.

" We forget this. We feel, in a way, that the wireless is like a gramophone—that it is doing something of its own accord. It is doing nothing of its own accord. It is merely repeating a lesson.

" This, when you really grasp it, is an awful thought. For this silence—this blankness, emptiness, which surrounds us in our quiet room, is a tempest of melody. The air is drenched with music, dizzy with song. The ether is a wild medley of voices, laughing, crying, sobbing, entreating. *Is*, I said. Not ' would be, if we turned on the wireless '. It *is*, whether we turn on the wireless or not. Schubert is in the room, and Mozart, and Beethoven, and the song of the nightingale, and all the music of this earth. And voices pleading, and voices angry, and voices that whisper, and are sad. And we sit there, wrapped in silence."

This is all very strikingly expressed and realistic, but what has it to do with the supernatural?

Great Men of Science

Who have been the world's half-dozen greatest men of Science? My own choice would be the Greek **Archimedes** (287–212 B.C.), the Italian **Galileo** (1564–1642), the Englishman **Newton** (1642–1727), the Englishman **Faraday** (1791–1867), the Englishman **Darwin** (1809–82), and the Frenchman **Pasteur** (1822–95). Inasmuch as three of the six are Englishmen, it would be natural for foreigners to disagree with the choice though it is doubtful if greater names could be found. That there have been possibly greater geniuses in other departments of life must be admitted; the Greek **Aristotle,** the Englishman **Shakespeare,** the Frenchman **Pascal,** and the Italian **Leonardo da Vinci,** for instance. But how can just comparisons be drawn? Leonardo has been described as "the world's greatest genius": he was painter, sculptor, engineer, architect, inventor, everything, and in everything he outshone everybody. What other painter has ever succeeded in reproducing in a smile such inscrutability as is shown by Leonardo's *Mona Lisa* in the Louvre?

It would be easy to maintain that the greatest of the six men of science above-mentioned was the Greek Archimedes. He was, however, more of a mathematician than a man of science, and he never seemed able to divest himself of the apriorism which was so engrained in the Greek character. Galileo was another man who was head and shoulders above all his contemporaries. Greatly daring, he took a delight in flouting authority; time after time he proved that people in high places held absurd opinions—a dangerous thing to do in those days. His invention of the telescope was one of a hundred important original things he did, but how great that one! The Englishman Newton is unquestionably England's greatest genius. In experimental work he stood right in the front rank, as his book on optics proves. As a mathematician he has never been equalled, and his law of

gravitation is an amazing synthesis of observed facts. Think of it: the falling moon (the tangential force may here be ignored) and a falling stone proved to obey the same law! As an experimenter the Englishman Faraday stands quite alone; no physicist in the world has ever come near him in experimental resource and skill. And yet Faraday knew no mathematics! The Englishman Darwin collected a huge mass of biological facts and so classified them that he compelled the world to believe in the doctrine of evolution (how they hated him for it!), though not all later biologists are at one with Darwin as to the prime *cause* of evolution. No well-informed person now denies the *fact* of evolution. The Frenchman Pasteur, famous as a chemist, pathologist, and bacteriologist, showed wonderful scientific acumen and profound sagacity in tracking down micro-organisms. On the marble walls of the mausoleum built at the Pasteur Institute in Paris is an inscription consisting of a sentence from one of his own orations:

"Heureux celui qui porte en soi un Dieu, un idéal de beauté, et qui lui obéit—idéal de l'art, idéal de la science, idéal de la patrie, idéal des vertus de l'Evangile."

Some of my biological friends are certain to say that **Pavlov**, the Russian physiologist, ought to have been included in the half-dozen, but his work cannot yet be appraised objectively; opinions concerning it differ too strongly. That he was the world's foremost physiologist the wonderful organization of his great research school and the astonishing results there obtained on nervous activity seem clearly to prove. His philosophical outlook seems to have been a sort of half-way house between, on the one hand, rigorous behaviourism (in which thought is merely "dumb speech" and speech a type of automatic physical action), and, on the other, some sort of mind-and-body dualism. In his school Pavlov insisted on an exclusively experimental approach, and his experimental thoroughness and resource were extraordinary. So keen was he on the experimental approach that he would

actually fine his students for discussing any experimental result in psychological terms. He was devoted to science after the manner of Charles Darwin, whom he admired passionately, though unlike Darwin there was something of the mischievous imp in his nature; for instance, throughout the most austere years of the new Russia he used cheerfully to cross himself whenever he happened to pass the site of what had been a church. Luckily, Lenin admired him and forgave him everything.

To all these men, and of course to thousands of others, *new ideas* came, and many of them have proved wonderfully fruitful. How were these new ideas born? Who shall say? How can we analyse the delicate mental processes in the researcher's mind? The researcher seldom seems to be able to analyse them himself, for some of them are almost certainly hidden away in his subconscious mind and inarticulate, perhaps engaged in some sort of struggle to find clear expression. The researcher is usually very full of his subject, and known facts stand out in a bright light. He is thoroughly familiar with the thoughts and labours of former workers. Perhaps a new observation will supply him with a new fact, and this new fact placed with old facts will lead to a new train of thought; perhaps the old facts will rearrange themselves and present to the mind a picture which suggests a new idea. But successful research workers have great difficulty in explaining exactly how success comes. They admit that they try, they fail, they try again and fail again, perhaps a score of times. With each new effort there is perhaps greater care, and perhaps variation in procedure. "Suddenly there is a mental flash, and the idea comes." This is about all that the research worker can tell. Of course he can give a full account of the piece of research in which he has been engaged, but he finds it very difficult to say precisely how, or even exactly when, the *new idea* came to be born. We speak of the successful research worker as a gifted man, and if his success has been outstanding we say he is something of a genius.--We may let it go at that.

From Newton's *Opticks* we may gather much of his actual experimental procedure. The procedure impresses us, but behind it all we are driven to conclude that there was a master mind. So it is with Faraday's *Researches*.

There is often an element of chance in a great discovery, though we always feel that such a discovery would never have been made by an ordinary person.—James Clerk **Maxwell**, the first Cavendish Professor at Cambridge, compared the strength of a current measured electromagnetically with the strength of a current measured electrostatically, and found that the ratio between the two magnitudes agreed numerically with the speed of light. The idea thus came to him that electromagnetic waves might be of the same nature as light waves, an agreement which led to his famous electromagnetic theory of light. Maxwell failed to produce the waves experimentally, but, later, **Hertz** made his brilliant experiment with ultra-rapid electric oscillations, and Maxwell's hypothesis was thenceforth recognized universally. The interesting point about this is that Maxwell made his original comparison quite by chance (his Cavendish assistant, William Garnett,* told me so himself), but one cannot help thinking that it was the innate genius of the man that led him to make such a comparison. He had probably divined beforehand that the two things might be one; Faraday's researches had for years given him food for serious thought, and gave his mind the necessary direction.

3. The Methods of Science

But fruitful ideas seldom come even to the ablest men unless their work is systematic and conducted in accordance with the principles of a well-recognized general procedure. What is this procedure?

The first thing is to obtain all possible *facts*, to grasp their significance, and to describe them in terms which

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admit of no ambiguity. The layman often finds the terminology of science a little repellent, but the men of science usually hesitate to use an old term for a new phenomenon. That old term will almost certainly be associated with old ideas, perhaps even be charged with emotion of some kind, and a new term is therefore required to express the new phenomenon coldly and precisely.

The next thing is to *classify* the facts, in the hope that a rational grouping will lead to the suggestion of some sort of principle or law. But, clearly, different forms of classification are nearly always possible, and even at this stage the worker may betray a personal bias in the choice he makes.

The ordered classification of the facts may suggest that they are linked together by some sort of general *law*; for instance, the classified facts concerning the combination of chemical elements suggested the law of *constant proportions.*

It is natural for the worker now to ask, the human mind being what it is, what is behind the law, how can it be explained? Why, for instance, does the law of "constant proportions" hold good. No rational explanation being known, the worker hazards a guess, that is, he advances an *hypothesis.* He argues, for instance, that if all bodies consist of atoms, and if the atoms of any particular substance are all alike and have unvarying weights, the law of constant proportions becomes a simple derivative consequence of this hypothesis. The hypothesis seems to provide a simple natural explanation of the law. But before being accepted it must be tested, and this is done by deducing consequences which can be tested by observation. The atomic hypothesis has been tested on numberless occasions, and has been found to apply to all new chemical combinations whatsoever. It is therefore universally accepted. Still, atoms have never been actually seen, and the hypothesis is still only provisional, though the probability of its truth is exceedingly high.

All scientific laws are thus the results of *induction* from a large number of facts. *Deductions* may legitimately be made from both laws and hypotheses, but both the laws and

hypotheses are liable to be upset by the discovery of new facts, and then all the deductions that have been made from them become invalidated.

All scientific theory is just an embodiment of laws and hypotheses, and is *never more than provisional.* It is just a convenient setting for facts so far discovered. If new facts will not fit into it, it has to be modified, and some of its laws and hypotheses superseded. Indeed the whole theory may have to be superseded.

Galileo discovered the law of falling bodies, the law being a generalization from a comparatively small number of observed and measured instances. **Kepler** made observations of the motions of the planets, and from his data strove for years to determine their orbits. After an enormous amount of labour he formulated his three well-known laws. **Newton** made a much wider generalization than either Galileo or Kepler, and their laws were swallowed up in his single law of gravitation. This great law was just an embodiment of a vast number of observed facts, the result of a great induction; until then the facts had never seemed to have any sort of common linkage. Newton's law survived for 200 years, only to be swallowed up by a still wider generalization of facts, viz. the new gravitational law formulated by **Einstein.**

The key-note of Newton's method was his collection of facts, his classification of them, his inductions from them and his formulation of laws embracing them. He was very wary of hypotheses lest they should betray him, and he used them sparingly. But he could not avoid them altogether. In science, as in philosophy, nearly every so-called " explanation " is, at bottom, a guess, and is none the less a guess when it is called an hypothesis. From end to end science is full of guesses, though it is true the guesses are the result of prolonged and careful consideration of the facts. The " new idea " is eventually born; it *may* be stillborn, or it may prove to be a healthy infant.

Evidently there are limitations to the methods of science.

In the first place, what are "facts"? Even about this,

opinions differ radically. The very nature of our perceptions is still a question of hot debate, and our eyes and ears are such poor receptors that we are often unwittingly deceived. Few people realize how little is to be found in a sense datum and how largely we support it by unconscious inferences which we all unsuspiciously assume to be valid. In the second place, our inductions from collected facts may turn out to be wrong. A small boy may, for instance, have come across hundreds of cats in his short life and will have made the induction, though perhaps not in words, "all cats have tails". The first time he sees a Manx cat he is bound to throw his induction away. The invalidation of accepted old scientific inductions is by no means infrequent, because of the discovery of new facts.

But a more far-reaching limitation of scientific method is due to the dangers of *abstraction* and *hypothesis*.

The term *abstract* is sometimes used in antithesis to *concrete* but in science it more frequently signifies what is literally *abstracted*, i.e taken away, drawn off; it implies that there is always *something left*, and this is ever a source of danger. Science tends to argue about what it has abstracted as if it were arguing about the whole thing. More frequently than not it abstracts some common *metrical* property of a group of things, and ignores all their other properties. Physics, in particular, is far too prone to be satisfied with purely metrical schemes, symbolized in the form of equations. A physicist often handles these equations as if they were representative of the whole of concrete reality; he abstracts in one sense and treats the result as an abstraction in the other sense; he "draws off" and leaves all concreteness behind. Even Newton's three great laws are abstract laws; fundamentally they concern motion, abstracted from things moved.

Whereas an *abstraction* draws off some common quality detected in a number of diverse observations, an *hypothesis* invents some fictitious thing or idea in terms of which the observations may be collectively expressed. An abstraction subtracts, an hypothesis adds. Newton hated hypotheses

because of their fictitious character, but it is often impossible to correlate observations rationally unless an hypothesis is introduced. **Laplace's** nebular hypothesis seemed to account satisfactorily for the birth of the planets, but when examined from the point of view of dynamics it had to be rejected. *Avogadro's* hypothesis that equal volumes of gases under the same conditions of temperature and pressure contain the same number of molecules still holds; it explains perfectly some of the best-known quantitative laws in chemistry. Yet nobody has ever counted the quadrillions of molecules in an ordinary jar of gas, and probably never will. We have no possible means of verifying the hypothesis. **Darwin's** hypothesis of evolution is now almost universally accepted, for it correlates a vast number of facts perfectly, though of course no formal proof of evolution is possible. **Newton's** great law of gravitation was simply and satisfactorily explained for 200 years on the hypothesis that all bodies *attracted* one another, the measure of the attracting force being indicated by the law. But what is a *force*? What is it that pulls? Nobody suggests the presence of an intelligent pulling demon. The hypothesis of a "pull" seems to be utterly unjustified, but how else are we to explain the law? Physicists nowadays are very cautious of talking about forces, and they prefer to use the terms "moves towards" and "moves away from" rather than "attracts" and "repels"; they dread to be accused of inventing an unseen demon. They are probably right. But place an ordinary sewing needle on the table and let a common magnet approach it gradually. The needle gives a sudden jump, and adheres to the magnet. Yet to save the face of modern physics, we are bidden deny that the jump is due to any attractive force. Dynamics has been replaced by geometry, but it takes a great deal of geometry to explain that sudden jump of the needle.

Evidently hypotheses are of different types, but they all play useful parts in science, especially when they are made to serve the purpose of a natural setting for an obviously related group of varying facts. The danger is that we allow our

fictitious inventions to assume a reality; we forget that the chemist's atoms, the physicist's forces, and the biologist's genes are all fictions.

We should be on our guard against "explanations" in science, for at bottom they are nearly always more or less fraudulent. We are apt to think that because a particular experience has been correlated with more familiar experiences we know all about it. We forget how artfully the hypothetical demons we have invented may conceal themselves and yet how resourceful they may be in setting all our doubts at rest.

4. Mysticism in Modern Physics

Inasmuch as all physical experiences are based on our sense-perceptions, the first and most obvious system of classification of facts was in accordance with the perceptions derived from our respective senses, especially our senses of touch, sight, and hearing. It thus came about that physics was first divided into mechanics, acoustics, optics, heat, electricity and magnetism, these being treated as entirely different subjects. Gradually, however, it was seen that there was a close connexion between them, and that it was much simpler to establish exact physical laws if the senses were as far as possible ignored and attention was concentrated mainly on the events outside the senses; if, for instance, the sound waves emitted by a sounding body were dealt with mainly apart from the ear, if the rays of light emitted from a glowing body were dealt with mainly apart from the eye. (Unfortunately we do not possess an electrical sense.) This led to a new classification, e.g. heat waves were treated as though virtually identical with light waves; and thus it was a logical step to substitute suitable measuring instruments for the organs of sense. The eye gave way to the photographic film, the ear to the vibrating membrane, and the skin to the thermometer. We now use our sense organs

mainly for noting coincidences, for instance the coincidence of a galvanometer pointer with a mark on a graduated scale.

It used to be assumed that measurements gave all essential information about the nature of a physical event, and it was mainly in this way that classical physics obtained its imposing wealth of results.

The term classical physics has come to have a special significance. By the end of the nineteenth century, the superstructure of mechanics and physics, which had been placed on such firm foundations by Galileo and Newton, seemed almost complete. Faraday and Maxwell and their successors seemed to have built even better than they themselves had realized. The Laws of Motion, the Law of Gravitation, the great principles of the Conservation of Energy and of Momentum, the main Laws of Thermodynamics, the Undulatory theory of Young and Fresnel, the Electromagnetic theory of Clerk Maxwell, the values of the mass and of the charge of electrons, all these things were regarded as constituting a classical position which would stand four-square against any conceivable attack from any possible quarter. At the beginning of the present century, however, doubts began to arise.

It was then that physicists began to probe into things more deeply. They went below sense data. They assumed the reality of atoms and electrons, and they divided up space and time into infinitely small intervals. They soon found that the laws which applied to big things would not apply to small. The laws of macrophysics refused to shade off into the laws of microphysics. Something was wrong.

Let us consider a particular case of the older method and of the newer. A gas jar filled with a gas is fitted with a movable piston. The classical physicist knew all that he wanted to know about the condition of the gas if he knew (1) the pressure exerted on the sides of the vessel by the gas, (2) the temperature of the gas, (3) the volume occupied by the gas. These data told him all that he considered worth knowing about the condition of the gas. He was quite in-

different to the number of molecules of the gas or about what the individual molecules might be doing. But the modern physicist is not so satisfied. He knows that there are quadrillions of molecules present and he wants to know all about *them*. If his knowledge of them at any particular moment is to be complete, he has to know about each and every molecule (1) the position it occupies, (2) its velocity, (3) its direction of motion. And if he is a chemist he wants to know a great deal more. Evidently the newer conception of what is going on in the gas jar is immensely more complicated than the older. But we have no power of seeing or handling the separate molecules, and *we cannot get at the actual facts.* The arguments of the modern physicist are necessarily based *on mere average effects.*

Roughly analogous cases may readily be found in the every-day world. The general effects of the words of an orator on a big crowd may be gauged pretty accurately, but their effect on any particular individual cannot. Whether the grass of a field will grow or wither it is easy to forecast, but whether a particular blade of grass will grow or wither it is impossible to say. Previous statistics afford reasonable certainty that a definite proportion of people will die next year, but whether any particular person will die we are quite uncertain. Accurate statistical investigations underlie the work of all insurance companies.

Mathematicians are constantly dealing with *averages*, and even "chance" or "random" effects they often reduce to law. The mathematical theory of probability is universally recognized as rational and scientific. Fundamentally, the theory of probability consists in putting similar things on an equality and distributing equally among them whatever knowledge we possess. Throw up a penny: it will undoubtedly fall head or tail: that we *know*, but whether it will be head or tail our knowledge is equally divided. Mathematics has worked out *laws* of probability, and it is remarkable what accurate forecasts may be made by them. But probability can never forecast what will happen in any named case; it cannot

reduce chance to certainty, though it may forecast with a very high degree of probability. "Randomness" now enters very largely into modern physics; the "certainty" of the older physics has passed away, and has been largely replaced by "probability".

To the layman modern physics is full of mysteries. Certainly it is full of difficulties, mainly of a mathematical nature, and we can only touch upon them in a very general way.

Classical physics postulated an all-pervading aether. It was known that light travelled to us from the sun at the rate of 186,000 miles a second. How did it come? Something must have brought it. Light was believed to consist of waves and the aether was postulated as the necessary wave-carrying medium. But in view of the enormous velocity of light, the aether had to be given properties that made people rather doubtful about its existence, for of course its existence as an entity could neither be demonstrated nor imagined. However, it was strongly sponsored by Sir Oliver Lodge and other well-known physicists, and it survived in all its robustness until the close of the War. Since then it has been much assailed by mathematicians and by some physicists; and though greatly attenuated it has for some years been masquerading under the name of "space-time".

If I stand on a railway embankment whilst a train travelling at the rate of 60 miles an hour passes me, and if at the same time a passenger walks forward along the corridor at the rate of 3 miles an hour, the passenger will pass me on the embankment at the rate of 63 miles an hour. Such a compounding of velocities is well-known to every schoolboy, and it was believed to be applicable to all moving things in all circumstances. It is just a case of mere addition (or subtraction).

If, then, we are travelling in a motor-car at the rate of 100 miles an hour and we turn on the headlights, the light will presumably travel at the rate of $\{(186{,}000 \times 60 \times 60) + 100\}$ miles an hour.

But this simply does not happen, as was experimentally

proved by Michelson and Morley, two American physicists, who used for the purpose a very delicately made interferometer. The experiment was conclusive and it is no longer questioned. When light is emitted, no matter how strong an initial push is given it, backwards or forwards—in other words, no matter how quickly or in what direction the hot body emitting the light may be travelling, the light itself settles down *at once* to move with a velocity of 186,000 miles a second, never more, never less.

Physicists were nonplussed. They could neither explain such a result nor explain it away.

Then the famous German physicist, Einstein, appeared on the scene (alas! Germany no longer recognizes him). He accepted as *true* the newly discovered constant velocity of light. He did more: he told physicists that they had always made the mistake of forgetting that their "reference-frame" from which they made all their measurements, viz. the earth, was not a fixed body but was itself *moving*. And inasmuch as *all* bodies are moving, all motion is *relative*, a fact which necessitates the recognition of the principle which some people are still inclined to distrust, viz. Relativity.

The subject of Relativity is really too recondite for the non-mathematician, who necessarily has to be satisfied with a general understanding of a few of its broader principles. As we saw in the section on "space-time" in the previous chapter, even the Relativity of simultaneity is a little difficult to grasp; it demands a surrender of some of our old notions. And we have already pointed out that we cannot logically deal with space and time separately. Even our own *where* and *when* are always associated, as in the very headings of our letters or in our preparations for a holiday. The mysterious aether has thus come to be replaced by the more plausible *space-time*, and not only is the aether thus dethroned, but the "force" of gravitation as well. Yet the space of space-time must not even now be thought of as a structureless nothingness. Somehow space-time *directs* the motions of bodies, whether the bodies are uniform or accelerated, but Relativity's explana-

tion of that directing is profoundly obscure. A moving body (and all bodies are in motion) is now said to pursue its course along its own "world-lines", straight lines if its motion is uniform, curved lines if its motion is accelerated. A thing's world-lines are forbidding indeed. If moving on the earth, the thing has a motion relative to the earth, the earth has a motion relative to the sun, the sun to our galaxy, our own galaxy to all the other galaxies. Those world-lines may perhaps have freed themselves from forces, but think of their geometry! Indeed, the mathematics of Relativity conceals all too effectually any rational explanations of the phenomena enshrined in its symbolism.

A second topic in modern Physics that puzzles the layman is the *Quantum Theory*.

Consider an ordinary piece of metal, say iron. Its molecules are packed in orderly array, very close together, but actually separate as individuals. Though in character apparently continuous, the solid structure is really *discontinuous*. So it is with water; the molecules move freely over one another, but they are really *discontinuous*, despite the apparent continuity of the liquid. So it is with air; push a piston into a gas-jar and we experience an opposing pressure; we feel that the increased pressure we exert is increased continuously, but we have good reason to believe that the molecules of air are bombarding the piston by separate blows and that the air is therefore *discontinuous*.

A common object on the pier at a seaside place is a penny-in-the-slot machine known as a "punch-ball"; a dial records in pounds and ounces the energy of the punch delivered by some enterprising youth. Now it is inconceivable that the dial will always register an *exact* number of pounds or of pounds and ounces. From the nature of things we are inclined to believe that our muscular effort is not to be measured by anything of the nature of a succession of steps, no matter how small these steps may be. Whatever we may say about the *discontinuity* of solids, liquids, and gases, we

claim that an exerted force of any kind is necessarily *continuous*, one amount shading off imperceptibly into another, and not that one amount is separated from the next amount by a sort of empty interval.

This imperceptible shading off may perhaps be admitted in all kinds of human effort, but in physical science anything of the nature of " continuity of energy " the Quantum theory challenges

According to the classical laws of electrodynamics, the energy of an atom should continually decrease, owing to the atom scattering energy abroad in the form of radiation and therefore retaining less and less for itself. The same laws predicted that all energy set free in space would rapidly become transformed into radiation of almost infinitesimal wave-length. But just at the end of the last century experiments proved conclusively that these things simply did not happen. For instance, experiments seemed to show quite clearly that the successive orbits of the electrons within the miniature solar-like system of the atom were characterized by definite energy differences, and that these differences were constant and never shaded off one into the other. No theory of *continuous* emission of energy was possible. Either definite portions of energy are emitted, or none at all. Regularity and law remain, but everything takes place in *steps*, in *gushes*, though the steps are not necessarily equal. Planck's *quantum*, an accurately measurable constant, easily explained everything. Max Planck, Professor of Physics at Berlin, assumed that all kinds of radiation are emitted by systems of *vibrators* which, on being excited, emit light. According to the classical theory each vibrator should *gradually* come to rest and then stop until excited again, but Planck assumed, instead, that every vibrator always changed its energy by sudden *jerks*. This vibrator might have any integral number of units of energy but no fractions. Thus changes of energy are *never gradual* but are delivered in sudden gushes. In this way " gradualness was driven out of physics and discontinuity took its place ".

The Quantum theory really arose as a means of an escape from the *impasse* reached by classical physics in 1900 in connexion with the laws of radiant heat. The theory also helped to solve other problems in physics, problems which were causing unmistakable difficulties in the classical theory, especially ionization, chemical reactions, and photoelectric phenomena.

The important point is that the Quantum theory unequivocally denies certain fundamental views essential to the whole structure of traditional classical physical theory. Briefly, it denies continuity, and it asserts discontinuity. This is its main axiom; everything else in the theory is merely consequential.

But though the Quantum Theory denies continuity in nature, the discontinuity it allows is of an amazing degree of fineness. Planck's constant is commonly written

$$h = 6{\cdot}55 \times 10^{-27} \text{ or } 6{\cdot}55/10^{27}.$$

The reader may find it helpful to ponder over an illustration of this kind. If a staircase were constructed to extend through a vertical height of 92,000,000 miles (the distance from the earth to the sun), and if the vertical rise of each step was $1/10^{27}$ (the denominator of Planck's constant) of the whole, there would be roughly *a hundred billion steps to the inch.* Truly a gently rising staircase! But no illustration of the minuteness of Planck's constant is likely to help the non-mathematician very much.

Planck's hypothesis, though utterly at variance with many of our intuitive notions, is undoubtedly well supported by physical facts. The mathematical consequences of the hypothesis agree with the results of experiment in many cases where the assumption of continuity leads to wrong results. The vast majority of physicists now regard the Quantum theory as definitely established.

If we accept the Quantum theory, the old saw: "Nature never makes a leap" (*natura saltum non facit*), must be replaced by its converse: "Nature *always* proceeds in leaps."

We are asked to believe that Nature never flows, never glides; she always proceeds by jumps. After all, the Quantum theory is perhaps hardly so astonishing as at first sight it seems to be. We have been aware of the granular structure of *matter* for a long time, yet in our mathematical physics—for example in such subjects as elasticity and conduction of heat—we have been accustomed to deal with a smoothed out, ideally continuous substitute for matter, because we found that this was quite sufficient for the purpose, so long as we confined our attention, as we practically always did, to phenomena on the large scale. The Quantum theory means, at bottom, that our knowledge of the minute structure of bodies has now come to a point where this ideal smoothing out will no longer do.

A third mystifying topic in modern Physics is *wave-mechanics* with which is closely associated the so-called "Principle of Uncertainty".

Newton thought that light consisted of *corpuscles* of some kind, and by means of them he was able to explain most light phenomena satisfactorily. But they did not enable him to explain interference and diffraction, and the hypothesis of corpuscles eventually gave way to the hypothesis of *waves*, originated and developed by Huygens, Young, and Fresnel. The wave hypothesis survived until the beginning of the present century, and then arose doubts which caused Einstein to revive the hypothesis of corpuscles though in the form of light *quanta*. Einstein's light quantum, the *photon*, was a sort of atom of radiation, possessing energy of the amount $h\nu$, where h is Planck's constant, and ν is the frequency of the radiation.

For the last thirty years physicists have been busily engaged in trying to come to a decision concerning the rival claims of corpuscles and waves to be regarded as the fundamental constituents of light. Generally speaking, optical effects point to waves and electrical effects to corpuscles. Some physicists have fought for corpuscles, some for waves,

but all seem now to be convinced that the exclusive claims, either of corpuscles or of waves, must be rejected, and that a compromise must be found.

"Uncertainty" has in fact invaded modern physics to such an extent that it has been reduced—perhaps we should say "elevated"—to a *Principle.* Underlying the notion is the apparent impossibility of deciding experimentally the question of particles *versus* waves.

Suppose, for instance, we wish to determine the relative *positions* and *velocities* of a number of particles, say electrons. Theoretically, there is no difficulty in doing this to any required degree of accuracy, but when we attempt to devise the necessary experiment, physical limitations arise which impose definite limitations on the accuracy we can obtain.

We have, of course, to make the electrons visible by some means, and we therefore employ a microscope supplied with light in the usual way. In practice we should necessarily view vast multitudes of electrons at the same time, but we may argue the case logically as if we viewed only a single one.

The light we use is the real source of trouble. We see the electron by the light which it scatters, and the very least it can scatter is a single photon.

First, consider the *position* of the electron. We cannot fix the position with absolute exactness, because the image of the point appears in the focal plane of the microscope, not as a point, but as a disc, *the diameter of which is directly proportional to the wave-length of the light used.* Actually, of course, we are dealing with a huge multitude of electrons, and we shall therefore have a huge multitude of overlapping discs, and the only way of meeting this difficulty and of making accurate observations is by using light of very small wave-length, say ultra-violet light.

But—and here is the real trouble—the light we use *itself possesses momentum* and thus imparts momentum to the electrons. The shorter the wave-length of light, the greater its momentum. If, then, in order to obtain a clear image of the electrons we use light of very short wave-length, the

light itself introduces much disturbing momentum. If on the other hand, we try to keep down the errors of momentum, by using, for instance, red-light with its longer wave-length, the image becomes confused, and the fixing of exact position becomes hopeless. In any circumstances the electron receives from the light which it scatters a more or less violent kick, and it can be shown that the change in the electron's velocity due to the kick *is inversely proportional to the wave-length of the light used.* Thus the smaller the uncertainty of position, the greater the uncertainty of momentum; and vice versa.

To summarize: If we measure the *position* of the electron accurately, we shall measure its *momentum* very inaccurately, because of the disturbances caused by the outside momentum received from the light. If we measure the *momentum* of the electron accurately by using light which introduces little outside momentum, there will be serious errors in the measurement of *position.*

All this sounds like a cunningly devised plot on the part of nature to prevent our seeing the locality and the motion of the electron within the atom. In such circumstances it seems reasonable to ask, *Is* there such a locality? But a question much more to the point is, *Is there such a thing in all nature as an exact position being associated with exact momentum?* It certainly seems doubtful.

Ordinary experiments with gross matter are made with instruments so designed that they do not perceptibly disturb the object measured. When, however, we try to experiment with electrons, such non-disturbance is impossible; as we have just seen, the very light we use—and we are bound to use it—scatters them in all directions. Moreover, the distances to be measured in atomic physics are unimaginably minute, though the ingenuity of physicists almost leads us to believe that there is scarcely any limit to the accuracy with which they may determine either position or momentum. In actual practice, however, the two measurements of position and momentum always seem to interfere with each other, so that the combination of the measurements

legitimate in large-scale physics, becomes indefinable and impossible on the small scale. As we have said before, it is clearly impossible to identify and measure a single electron; we always have to deal with vast multitudes, and to deduce as best we can the sizes, velocities, &c., of individuals. But such results imply, not certainty, but only probability.

For reasons which we shall discuss later, the term "Uncertainty" is preferable to the term "Indeterminacy" when applied to the questions we have been discussing.

We now come to the main question: can waves and particles be merged, and be conceived as a single entity?

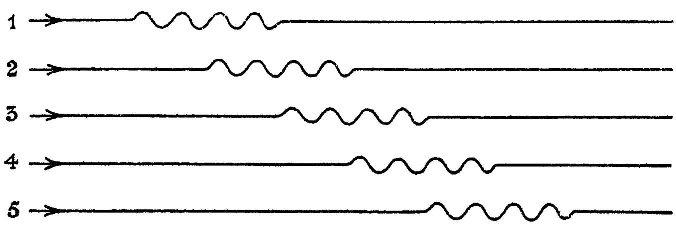


Fig. 45.—Travelling wave-packet. Positions at successive minute intervals of time

We may conveniently think of an ordinary wave-train with its crests and troughs, concentrate our attention upon a particular group of these crests and troughs, in which the energy is specially concentrated, and ignore the remainder. Such a group is sometimes called a *wave-packet*. Fig. 45 shows diagrammatically a wave-packet travelling to the right. We conceive the electron *as somewhere within the wave-packet*, but precisely where we cannot tell. We think of a particle as associated with a wave, but it is impossible to know where in the wave it is. All we can be reasonably certain about is that the electron is *somewhere* in the wave-packet. To this, as to everything else in wave mechanics, the Uncertainty Principle applies. We are not supposed to think of the electron as a sort of solid ball travelling round a circular or elliptical tube. The travelling thing is the wave-

packet, and somewhere in the packet is its sister-self, the two Siamese sisters being called a *wavicle* (WAVe-partICLE).

We may provide ourselves with a rough analogy by considering the appearance of a white spot chalked or painted on the tyre of a motor-car. The car begins to move and the white spot begins to revolve and appears to lengthen. As the car increases in speed, the white spot acquires the appearance of a complete circle; a rather hazy circle, it is true, especially at the edges. The hazy circle is analogous to the revolving wave-packet; the white spot itself, now lost but known to be still there, is analogous to the electron as a particle. Such an analogy must not be pressed very far, as the differences from the real wavicle are much greater than the resemblances. Modern physics has given birth to many strange children, many of them petted and spoilt, but the wavicle is by far the greatest general pet at present. And yet physicists are one and all afraid of it. "What is it really like?" they say. "If we seek its intimate acquaintance, will it let us down very badly?" It probably will.

No exact description of a wavicle is possible. What we have to *try* to do is to think of a wave system in which the individual waves cancel each other out by interference everywhere except at just one place, where they intensify one another. We may, if we please, look on this wave-point of intensity as giving birth to the electron as a particle; or we may, again if we please, look on the electron as a particle giving birth to a train of waves. Honestly we cannot distinguish parent and child. One rather caustic critic says: "It is all very much like trying to localize a violent agitation amongst the waves of a stormy sea. It seems to be now here, now there, now gone, now reappeared elsewhere, ever fugitive and escapable. There seems to be a disturbing entity of *some* kind, but it is unknown, and therefore neither describable nor definable. The physicists call this elusive entity in the waves 'ψ'. If you want to make a 'modern' physicist really angry, ask him to describe ψ in exact language. To one physicist, ψ is a 'singularity'; to another, a 'wave-

function'; to a third a 'field symbol'; to a fourth, a 'probability'; to a fifth, an 'elementary indefinable'. To the mathematician ψ is a thing of joy, to the physicist a thing of terror."

The main problem is now in the hands of the mathematicians, and for the last ten or twelve years a group of young mathematicians have been wrestling with it. We ought perhaps to call them mathematical physicists, for most of them seem to be almost equally at home in both subjects.

The most distinguished of them are **de Broglie,** a Frenchman; **Schrödinger** and **Heisenberg,** Germans; and **Dirac,** an Englishman.

De Broglie virtually accepted the wave-packet hypothesis and made it his starting point. His view was that *any moving particle must be accompanied by a wave*, and he assumed that *the wave must control the motion of the particle.* Thus instead of Newton's laws of motion (which admittedly still hold good for the large-scale phenomena of everyday life), de Broglie substituted **a motion governed by waves,** and this is the basic idea of "wave mechanics". As de Broglie himself put it: "The object of the wave mechanics is to create a synthesis embracing (1) the dynamics of a material particle, and (2) the theory of waves as conceived by Fresnel. On the one hand, the effect of this synthesis must be to introduce into optics the idea of *points of concentration of radiant energy*, an idea which seems to be required by the recent results of experimental physics; on the other hand it must introduce *the conceptions of the theory of waves into our picture of material particles*, in order to account for the occurrence of quanta in mechanics, and for intra-atomic phenomena."

Schrödinger used de Broglie's theory to build up wave mechanics into a rigorous mathematical system, a system which at first sight does seem to reduce to some kind of order the chaos of explanations of the properties of atoms; and at first sight it also seems to lend itself to physical interpretation, fusing waves and particles together into a sort of entity which can be visualized. This of course is satisfying

because we can describe in exact language the picture we have conjured up. But alas! the waves which eventually emerge from the equations are only "probability" waves, as they have been gravely called, and the picture refuses to materialize. In short, the scheme has broken down. It is not, by a very long way, representative of all the known facts, and it was bound to break down in any case.

Even before Schrödinger had completely worked out this theory, Heisenberg put forward an entirely new and original scheme. He rejected the wave-packet idea entirely, being strongly suspicious of it because it contained an element of the unobservable. He maintained that, since all our knowledge of the interior of the atom comes to us from the study of spectra, any rational scheme of interpretation must start off with a representation of the atom by means of quantities directly connected with *actually observed* spectral frequencies. So far, excellent. But the theory is embodied in a very forbidding mathematical dress and is quite beyond the comprehension of the non-mathematician. Dirac, the present holder of Newton's chair at Cambridge, went even further and devised a mathematical scheme which presents very great difficulties, and it is significant that the term "transcendent" has been applied to it, which is a polite way of saying that it is beyond the comprehension of all ordinary people. There is, however, no doubt that the scheme embodies a wonderfully complete and coherent system for codifying all our metrical knowledge of "wavicles". A *physical* interpretation of either Heisenberg's or Dirac's scheme seems impossible, but we cannot withold our admiration of the mathematical craftsmen who have been able to crowd such a mass of metrical facts into a symbolism of so neat and compact a form.

Here is the principal formula concerned:

$$qp - pq = ih/2\pi.$$

The symbols on the right hand are familiar enough; h is Planck's constant, i (or $\sqrt{-1}$) is an old friend from trigo-

nometry, and π is another from very elementary mathematics. But what about p and q on the left-hand side? We may *call* them co-ordinates and momenta, but that gives no sort of explanation why qp is not equal to pq, or why $qp - pq$ is not equal to 0. Quite obviously q and p cannot represent simple numerical measures.

Eddington puts it this way: For Schrödinger, p is an *operator*. His " momentum " is not a quantity, but a signal to us to perform a certain mathematical operation on any quantities which may follow. For Heisenberg, Born, and Jordan, p is a matrix, an infinite number of quantities set out in systematic array. For Dirac, p is a symbol without any kind of numerical interpretation; he calls it a q number, which is another way of saying that it is not a number at all.

We are bidden to give up our craving for clear visualization, and to be satisfied with symbols. But how can the mind ever find repose in symbolism?

Physicists seem to be convinced that the interaction between radiation and matter in single quanta is something lying at the very root of physics, but what that interaction is they readily admit they do not know; the symbols refuse to reveal their secret.

Waves? Particles? or Wavicles?

Waves?—We go out on a cloudless night and " see " a multitude of stars. We believe that " light " (whatever light may be) from every one of them has been travelling with a velocity of 186,000 miles a second, and that from the very nearest (*Proxima Centauri*) it has taken over four years to reach us. Imagine a light-wave (as we will call it) set up as the result of a single emission from a single electron in a single atom in a star, say ten light-years distant. The energy of the wave has ever since been spreading over an ever-extending sphere, which, after 10 years, must have a radius of about sixty billion miles. If at the appropriate moment at the end of the ten years we are looking in the right direction, that wave, weakened to an inconceivably insignificant degree since its start, strikes the retinæ of our eyes and we " see "

the star. But how? Is it conceivable that the wave will deliver a whole quantum of light? If it delivers less, nothing is supposed to happen. One explanation suggested is that if, say, one quadrillionth of a light quantum is brought within range of each atom of our retinæ, one atom out of every quadrillion in the retinæ will absorb a whole quantum. Alternatively, what the light-waves are really bringing within reach of each atom is not a quadrillionth of a quantum but the quadrillionth of a "chance" of delivering a whole quantum. This "propagation of chance", bizarre as it seems, has been put forward in all seriousness.

Particles?—Alternatively, let us imagine a particle, a light-corpuscle, a photon, starting from the atom in the star, and, after its sixty-billion-mile journey, finding itself not too weary to interact with an atom in our retinæ and enable us to catch a glimpse of its parent who kicked it out ten years before.

Wavicles?—No, no, no.

Said a well-trained and intelligent Sixth Form boy to me recently, "A few of our leading mathematicians seem to have got Physics into a most unholy mess. Have they ever actually *measured* anything."

Intelligent schoolboys still have a sturdy faith in Newton and Faraday. So have science teachers, no mean judges. Meanwhile such master physicists as Lord Rutherford and Sir William Bragg are getting on with their jobs, and supplying the mathematicians with more and more facts, facts which are likely some day to lead to the destruction of the present provisional symbolical hypotheses, which are so profoundly unsatisfactory and are bound eventually to be superseded.

5. Biology and Biologists

If the reader is to understand the inner significance of present-day biological controversy he must first familiarize

himself with some of the principal biological developments of the present century.

It has probably not occurred to the average educated man what an extremely important part biological science plays in the modern civilized state. It will suffice here to mention just two points: (1) the provision of food for the community —crop-raising, stock-breeding, dairy products, fisheries, and the preservation of food by canning and freezing; (2) the maintenance of the health of the community—the prevention of disease, the war on parasitic microbes, and the cure of disease by the modern methods of medicine and surgery. Obviously all these things are immensely complicated applications of biological science.

The student of biology should always bear in mind three guiding principles: (1) *the great fact of evolution* (it is *probably* a fact) and its far-reaching implications, especially nature's struggle for existence and the elimination of the unfit; (2) *the great fact of inheritance*—the fact that the child repeats the physical, mental, and moral characteristics of the parent, but that this repetition is never so complete as to amount to identity of such characteristics; (3) *the great fact of the biology of communal life*, not only as presented by cell communities of social insects, such as bees and ants, but also (which is of far greater importance) as presented by cell communities constituting the bodies of all animals and plants, except the few single-celled organisms at the very bottom of the scale. A living animal or plant is an amazingly well-organized community of vast numbers of cells, every cell a perfect physical and chemical laboratory, every cell doing specialized work, the whole directed and co-ordinated in some unknown way but with such perfection that human society can never hope to emulate it.

The first and most obvious division of biology is into the two studies of plants and animals, Botany and Zoology respectively. The broad distinction between plants and animals is that plants contain chlorophyll and cellulose, and make their own starch and sugar, while most animals have to

depend, directly or indirectly, upon plants for their food. But both plants and animals may be considered from two points of view, that of *form* and that of *function*; the former is the business of anatomy, the latter of physiology. The study of the early stages in the growth of the organism, its organs, and its tissues, is called Embryology (Greek ἔμβρυον, embryo, fetus), which includes both the anatomy and the physiology of the developing organism.*

Although life is limited to the individual, it is continued in the race, and this suggests the studies of **Evolution** and **Heredity. Genetics** is intimately connected with the study of Heredity; its problems are those of the ways in which offspring inherit certain characteristics and yet at the same time have individual differences. **Eugenics** has for its aim the perpetuation of those inherent and hereditary qualities which aid in the development of the human race. The study of the diseases of organisms has for its basis the study of **Bacteriology.**

Professor E. C. C. Baly of Liverpool has been able to produce a trace of sugar (an organic compound) out of nothing but water, carbon dioxide, and light. The carbon dioxide was bubbled through water which was exposed to visible light and which contained suspended particles of cobalt carbonate. The particles took no part in the reaction, but the CO_2 became concentrated on their surfaces and was then photo-synthesized. The particles were mere catalysts. —Can we infer from this experimental fact that we have a clue to Nature's original method of initiating a life-process?

As far as we can tell, every new living thing is derived from pre-existent living things; in other words, every living thing must have had parents. And yet there must have been a time when the condition of this planet was such that life on it was impossible. How then did life first make its appearance? It is no answer to say that the chemist is now able to synthesize many organic compounds; he has not come

* The anatomist's subject is *Morphology* (Greek, μορφή, form), the *static* side of biology The physiologist deals with the *dynamic* side of biology.

anywhere near synthesizing a compound that contains *life*. It will be many a long day before a living creature will be synthesized in a biochemical laboratory. Professor J. B. S. Haldane hopes to live long enough to see a pure enzyme made artificially, though (he says) "I do not think I shall behold the synthesis of anything so nearly alive as a bacteriophage or a virus, and I do not suppose that a self-contained organism will be made for centuries." Perhaps then we may allow a thousand centuries before the biochemist is able to perfect his process of artificial man-making.

It is just *possible* that if ever the secret of the beginning of life upon the earth is discovered, it will be traceable to the chlorophyll of the green plant. A plant feeds and grows, digests and breathes, as truly as an animal, and in regard to those main functions there is no essential difference between them. Both, too, are so far structurally alike that they are made of *cells*, and both originate in a fertilized egg-cell. Chlorophyll is the great transformer of the energy of sunlight into the energy of the organic colloids; and, directly or indirectly, the energy of all living things is traceable to this single source. Chlorophyll is itself a colloid and is far too complex to have arisen as a first step in the evolution of organic life. Of its actual origin we have no positive knowledge. As for living creatures there probably exist a whole world of them, far below the limits of the microscope, creatures originating from very complex protein molecules down among the colloids, leading up to the bacteria and protozoa which, comparatively speaking, are really highly developed organisms.

How did life originate? *We do not know*.

6. Embryology

We have said that, structurally, animals and plants are so far alike that they are made up of *cells*, i.e. microscopic bag-like units, more or less spherical in shape, each enclosed by a membrane (in the case of plants by a wall of cellulose).

Every cell contains a very complex organic compound of a colloidal nature called *protoplasm*, which is differentiated into (1) a transparent viscous *fluid* in which is embedded (2) the *nucleus* which has (3) a sort of attendant satellite, the *centrosome*. When during the development of an organism the cell attains a certain size, which varies for different cells, and may be from $\frac{1}{250}$ to $\frac{1}{12}$ of an inch in diameter, it divides into *two* cells, each complete with its own nucleus and centrosome. In the process of cell division, certain nuclear changes take place, and these are of the most impressive, far-reaching, and fundamental character. They must be clearly understood.

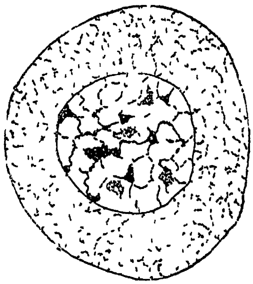


Fig. 46

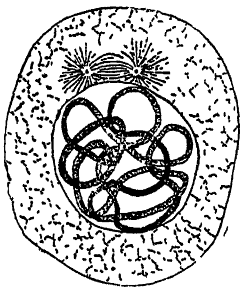


Fig 47

The process of cell-division is known as " mitosis " (Greek μίτος, a thread).

The nucleus of the cell has an enclosing membrane of its own, and within its fluid contents is a delicate *network*, on which during the resting phase of the cell there may be seen, under a high power of the microscope, numerous *granules* (fig. 46). These are the *chromatin* granules (Greek χρῶμα, colour), so called because they are easily and usefully coloured by stains: they play a fundamental part in cell-division. In the figure the minute star-like body called the *centrosome* (Greek σῶμα, a body) is seen to the top of and outside the nucleus which it adjoins.

Where the growing cell has reached a maximum size for the particular organism, remarkable changes take place in the

nucleus. The changes are perfectly regular, always similar in character, and always exactly the same for the same species, animal or plant. The successive changes are these:

1. The star-like centrosome divides into two, and the two halves, connected by radiating fibrils, move away from each other (fig. 47). At the same time,

2. The chromatin granules arrange themselves in a single long thread looking like a tangled skein (fig. 47)

3. The tangled chromatin thread breaks up into a definite number of short rods or loops (eight in the figure) called chromosomes (literally "coloured bodies") (fig 48). Simultaneously,

Fig 48

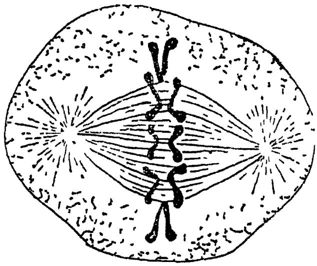


Fig 49

4. The two centrosomes continue to separate until they reach polar positions at opposite ends of a diameter of the nucleus; they are still connected by the radiating fibrils, which are now more or less semicircular (fig. 48).

5. The membrane of the nucleus disappears, each chromosome splits longitudinally and forms a kind of twin pair, and the various pairs arrange themselves, equatorial fashion, half-way between the "poles", the two centrosomes and their connecting fibres presenting the appearance of a spindle (fig. 49). (In the figure, for the sake of clearness, only five of the eight pairs are shown.)

6. Each equatorial set of chromosomes now moves off towards its nearer polar centrosome, and the stretching fibrils seem to part (fig. 50).

7. The two sets of chromosomes become quite separated, and each set forms a daughter nucleus; the cell as a whole begins to divide into two (fig. 51).

8. The chromosomes lose their rod and thread-like appearance and break up again into granules; a network is again

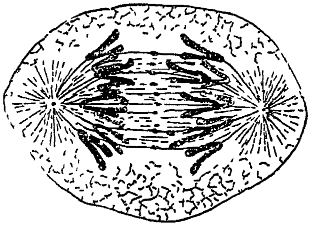


Fig 50

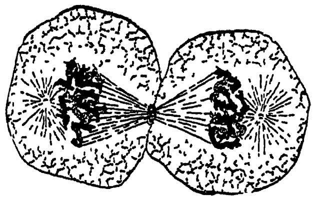


Fig 51

formed and each new nucleus becomes surrounded with a new membrane.

9. The cell-substance has also meanwhile divided, and we have at last two complete daughter cells, each exactly the same as the mother cell from which they were derived (figs. 46 and 52).

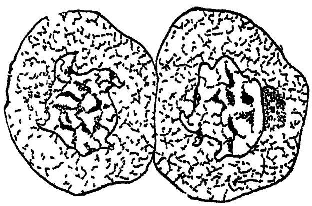


Fig. 52

Such is the process of mitosis. The process of division affects the *exact halving* of the chromatin substance, and results in each daughter cell having *the same number* of chromosomes as the original mother cell. The number of chromosomes in a cell is constant for every species of animal, although extremely variable for different species. Thus in the round worm of the horse (*ascaris megalocephala*) there are four; in man there are forty-eight. But in all animals,

man included, there is a sexual difference in chromosome numbers.

We may briefly consider the process of embryological development that applies to the vast majority of animals.

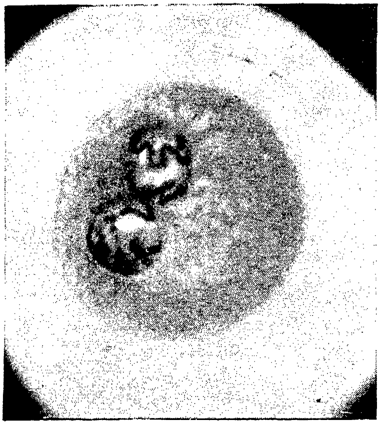
The bulk of the cells forming the body of an animal are ordinary *body cells*, but there is a minority of a more specific character, called *germ cells*. At first body cells and germ cells are much the same, but, during the process of growth, germ cells undergo a special kind of nuclear division which alters their nuclear constitution profoundly and renders them "mature". This process of maturation *halves the number of chromosomes* in both the male cell (*spermatozoon*) derived from the testis, and the female cell (*ovum*) derived from the ovary. When mature, but not before, these two cells are ready for conjugation, and their fusion into a compound cell, called a *zygote* (Greek *ζυγόν*, yoke, junction) is the essence of the sex-process termed fertilization. Even after the union, the chromosomes of male and female origin may be distinguished from one another.

The zygote forms the first body cell of the new animal, and it *contains the normal number of chromosomes*, half of which have been derived from the male parent and half from the female parent. The chromosome reduction process has resulted in the offspring receiving the total number of chromosomes possessed by each of the parents: thus the *species* is maintained.

The zygote (fertilized egg) once formed, mitosis begins in the usual way. The new cell divides into two, each of these into two and each of these again into two; and so the new animal is gradually built up (fig. 53).

Plate III shows untouched photo-micrographs of four stages of mitosis in *ascaris megalocephala*.

The reader should bear in mind that we are dealing with structures far below the range of the unaided vision. The microscopist has, however, so improved his technique that he can cut sections of some biological material a good deal less than one ten-thousandth of an inch in thickness and



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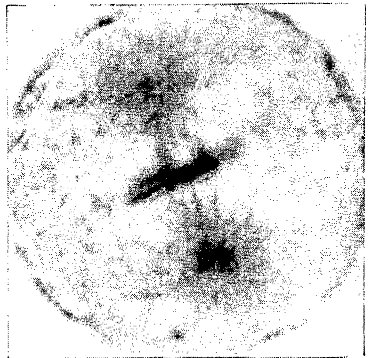

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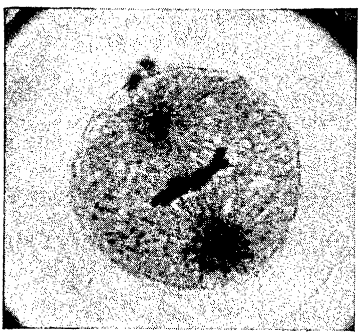

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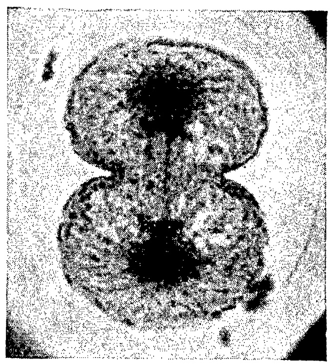

4

From untouched micro-photographs by D. A. Kempson

MITOSIS, beginning with an egg just fertilized. That of *Ascaris megalocephala* (the round worm from the intestine of the horse), which possesses two pairs of chromosomes.

1. Fertilization has just occurred. The nuclei of spermatozoa and ovum have just met. The chromosomes have begun to appear.
2. Side view of the equatorial plate stage of the first division of the fertilized egg. The spindle is seen with the centrosomes at the ends.
3. The chromosomes have split longitudinally.
4. The two sets of chromosomes have now moved apart to the two asters; the cell is deeply constricted and has almost reached the first cleavage stage.

From *Animal Biology*, Haldane and Huxley (The Clarendon Press)

Facing p. 252

obtain magnifications up to 1500 diameters. The pollen-grain of a lily is perhaps just visible to the naked eye, but it can be cut into fifty sections, photomicrographs of these can be made, and from the photomicrographs lantern slides which will show the pollen-grain sections ten feet long Only an expert with the microscope can make much of chromosome preparations, for the solid form of the objects has to be re-

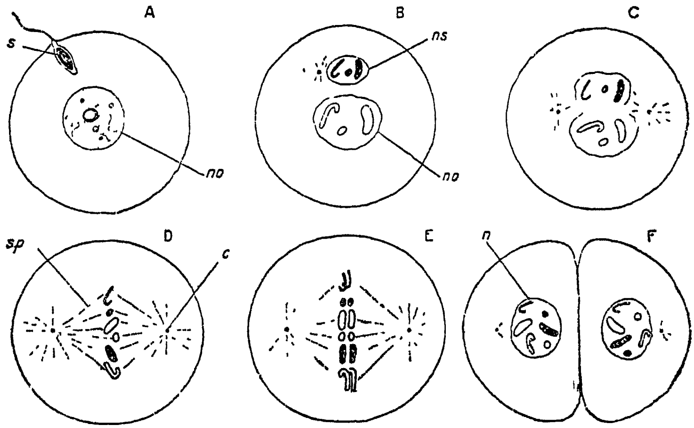

Fig 53 —Diagram showing fertilization A, The spermatozoon's head has entered the ovum B, The nucleus of the spermatozoon is swelling up and the chromosomes are appearing in both nuclei (haploid number = three) The spermatozoon is producing a spindle C, Fusion of the two nuclei D, The spindle is fully formed and all six ($2n$) chromosomes are arranged on its equator E, Mitosis sets in, all the chromosomes have split longitudinally F, The fertilized egg (zygote) has divided into two cells, each with the diploid ($2n$) number of chromosomes, one set of three (n) derived from the father in the spermatozoon, and the other set of three from the mother in the ovum.
From *Living Organisms*, Goodrich (The Clarendon Press)

constructed from images at different focuses, but the expert certainly can now get at the main facts about chromosomes.

When the sculptor makes his preliminary model perhaps of a future marble statue of a man, he takes a lump of clay, and moulds it gradually to shape; he first shapes it in the rough and then gradually moulds the details with greater and greater refinement. When nature sets out to model a future man, she does much the same thing: she first provides herself with material and then begins work as a modeller.

Her material to begin with is just a new zygote (fertilized cell). This cell she causes to multiply until she has a great mass of cells, and, when she begins to model, she constantly adds more and more cells until her model is completed She is thus doubly engaged; she is making cells, and she is moulding the masses of cells in accordance with a definite plan. No matter whether she is moulding a man or a dog or a bird or a fish or a fly, she begins in exactly the same way. So far as we can see, the fertilized cell with which she starts is always the same, save for its contained number of chromosomes. And to provide the necessary material she always seems to multiply that cell in precisely the same fashion. But there comes a time when she decides to give a specific individuality to the model she is making, and that individuality is always that of the parents of the particular fertilized cell. Exactly how she sets to work to differentiate, we do not know. So far she has succeeded in keeping her secret, but that secret *probably* lies in the chromosomes.

The newly fertilized egg (the zygote), a minute more or less spherical object, bears no sort of resemblance either to the animal that laid it or to the animal that fertilized it, or to the animal into which it will develop. The process of "development" is therefore concerned with the transformation of the egg into that form which we recognize as "the animal". The shape of the spherical egg is modified little by little, shape after shape succeeding one another until the adult shape is reached.

We may briefly trace the early stages of development from the zygote (fertilized egg). The early cell division is known as "segmentation". In a typical case the first cleavage takes place about an hour after fertilization, and occupies half an hour. The two new cells are similar and remain attached. Within another hour each of these new cells has divided and then we have a 4-celled embryo, the 4 cells lying in a ring, and in contact with one another. A third cleavage divides the 4 into 8, the plane of division being at right angles to the previous planes; all 4 cells are divided simul-

taneously. So the division proceeds, a doubling taking place at every stage: 16 cells, 32, 64, 128, and so on. The result is a ball-shaped mass of cells called a *morula* (Latin mulberry) (see fig. 54).

But the cells do not quite meet in the centre: there is a segmentation *cavity*, and as the morula grows, the cells arrange themselves in a single spherical layer round this cavity. The embryo at this stage is called a *blastula* (Greek

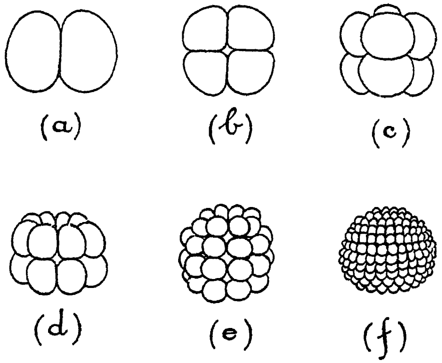

Fig 54.—Cleavage of the zygote by continual mitosis (a), 2-celled stage (from side) (b), 4-celled stage (from above) (c), 8-celled stage. (d), 16-celled stage (e), 32-celled stage (f), 128-celled stage (early morula)

The segmentation cavity begins at (c) The morula is a hollow sphere consisting of a single layer of cells.

βλαστός, a germ). It is, of course, much larger than the original zygote because during its cell multiplication and formation it has absorbed water and other materials from its surroundings. Fig. 55 (*a*) shows a transverse section of the blastula.

The larger cells on one side of the blastula will tend to sink into the cavity (fig. 55, *b*)—the blastula will be invaginated —and eventually a double-walled, two-layered cup will be formed, with an outer layer of small cells (the *ectoderm*), and an inner layer of larger cells (the *endoderm*). This cup-shaped embryo is called a *gastrula* (Greek γαστήρ, stomach)

(fig. 55, *c*). The ectoderm and endoderm form the two primitive *germinal layers*.

The cup closes, and the primitive food cavity is thus formed. On the dorsal surface the thickened edges rise up on either side to form a median groove, the *neural* groove (*d*),

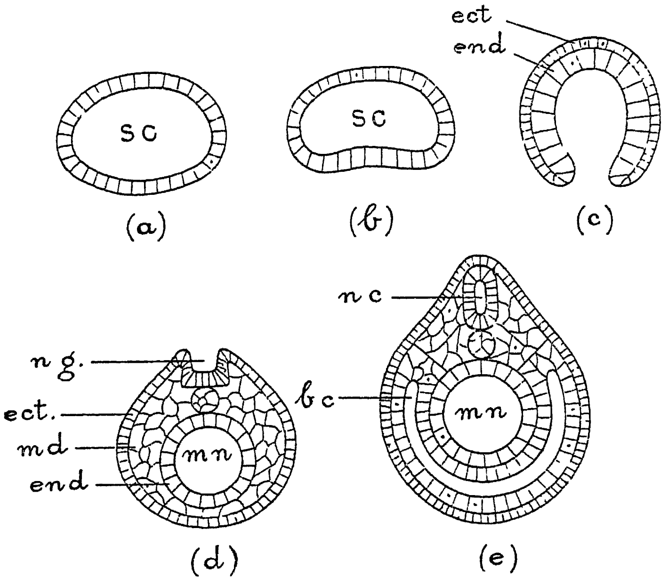

FIG 55.—Diagrams to show early stages of Embryological Development (a), Blastula, showing segmentation cavity (b), Blastula, beginning of invagination (c), Gastrula, showing primitive layers, ectoderm and endoderm (d), Establishment of mesenteron (digestive cavity) and neural groove (e), Formation of neural canal and body cavity.

ect, ectoderm; *end.*, endoderm, *md.*, mesoderm, *n g*, neural groove, *n c*, neural canal; *mn.*, mesenteron, *b c.*, body cavity, *s.c*, segmentation cavity.

and then close over above the groove to convert it into the *neural canal* (*e*). This is the first indication of the nervous system. The future body cavity is also indicated in (*e*) (fig. 55).

The endoderm gives rise to the inner layer of the alimentary canal and of the glands connected with it. The ectoderm forms the outer layer of the skin and gives rise to the central

nervous system and certain important structures connected with the sense organs. The mesoderm gives rise to the heart and blood-vessels, muscles, cartilages, and bones. External openings arise, often comparatively late in embryonic life, by the formation of external depressions meeting hollow outgrowths from the mesoderm, and from one of these the lungs, and the glands of the alimentary canal, arise, again as hollow outgrowths.

It should now be understood that all the organs are "roughed out" or "blocked out" by cell-divisions which take place in such a fashion that as the cells are formed they are marshalled into place much as a builder would assemble his materials preparatory to building a house. The food supply of the cells comes from the nutritive substances at the disposal of the embryo.

At the sixth week, the human embryo measures about $\frac{2}{5}$ inch in greatest diameter, and by that time there are developed at the head end the mouth, eyes, ears, and nasal cavities; and from each side two flattened buds have grown outwards —the rudiments of the upper and lower limbs. The marvel of it: a new organism tucked away in a spherical sac $\frac{2}{5}$ inch in diameter, yet already easily recognizable as a human being. Development now proceeds apace, and, about the middle of the fourth month of pregnancy, movements of the child, now almost fully formed, can be felt. From this time onwards, development consists almost entirely of mere increase in size.*

If the reader can obtain a little help from a biological friend, he may obtain a clear insight into embryology by examining hens' eggs taken from an incubator and studying the contained chick embryos. The egg is normally laid in the gastrula stage. The embryo may be studied whole, and most of the main structures may be easily identified during the first two or three days of incubation. Eggs may be opened every six or eight hours during the first four or five

* The embryos of the chick and the human being are pictorially compared in *The Endless Quest*, Plate 40.

days, and the gradual formation of the several organs easily observed. The best stages for early examination are those at the end of the 24th, 33rd, 48th, and 72nd hours.

The embryologists of the earlier half of the nineteenth century expressed the view that every animal, in its growth from the egg to the adult condition, passes in turn through stages which *recapitulate its evolution from a primitive form*, or in other words that *ontogeny* (the individual development) repeats *phylogeny* (the development of the race). The theory appeals strongly to the schoolboy who loves to think that "during its life history an animal climbs up the family tree".

We make up a phylogenetic or family tree by comparing the fully grown or *adult* shapes of one kind of animal with those of other kinds, and finding that they can be arranged in an order of increasing or decreasing complexity.

It is almost natural for the beginner in biology to compare the two series (1) the sequence of ontogenetic stages from zygote to adult in the case of some particular animal, and (2) the different adult forms of the succession of animals shown in that particular animal's family tree. Almost inevitably he draws the same inference as the earlier embryologist did, namely, that *if* evolution be a fact, *if* the family tree correctly indicates descent, each set of animals named in the tree must have "evolved" from the preceding set, and that therefore they must have followed exactly the same embryological route as the preceding set, and then have taken a sort of final evolutionary leap forward in order to obtain the new characteristics which distinguish them from the preceding set. Such an inference is perfectly logical, though of course it is based on the unverified assumption that nature always follows the old road. If nature *does* follow the old road, but decides to introduce a *variation*, she simply pulls up and takes a new turning. She never goes back to her starting-point (the zygote) and constructs an entirely new road.

But *does* nature always work in this fashion and follow the old familiar road?

The German embryologist **von Baer** came to the conclusion that animals are more similar at early stages of their development from the egg than when they are fully grown, and this resemblance between early stages becomes progressively diminished as they grow older. Thus a developing animal does not pass through the *adult* stages of other animals but moves away from them. Another famous German, **Haeckel,** was of the opinion that the adult stages of the ancestors are repeated during the development of the descendants but were crowded back into the earlier stages; there was an accelerated repetition. Thus the evolutionary novelty first appeared in the adult. But how does this square with, for instance, the fact that teeth were evolved before tongues, but in mammals tongues now develop before teeth? How could such a reversal of order come about during the accelerated repetition? In the second place, our rapidly increasing knowledge of the details of early stages of development tends to show more and more clearly that the early stages of quite closely related animals, such as the hen and the duck, may be distinguished. **Wilhelm His,** Professor of Pathology at Berlin, concludes that, even at these early stages, developing animals possess the characters of the class, order, species, and sex to which they belong. **Oskar Wertwig,** Professor of Comparative Anatomy at Berlin, maintains that the very zygote itself must have specific characters, although they may be invisible, and that the zygotes of different animals are really as distinct from one another as are their adults.

There seems to be no way of settling the question at present. The fossil record of animals is so imperfect that the few isolated forms we know are quite insufficient to indicate the road by which phylogeny has travelled.

7. Heredity

In the development of any organism we have to distinguish between the internal factors which are at work

inside it and the external factors which constitute its environment. Since the internal factors are present in the fertilized egg, they may be regarded as the transmitted factors, the passage of which from parent to offspring constitutes heredity. These internal factors are now called Mendelian factors or *genes*, and they are regarded as discrete units situated in the chromosomes of the cell nuclei. A change induced in one of these genes is called a *mutation*.

The study of mutation is the study of the principal problem of heredity.

The term **Heredity** implies that living organisms can produce their like. The resemblance, though never absolutely perfect, may extend to the most minute details of structure and function. It may be predicted confidently that a new zygote, formed by the fusion of ovum and spermatozoon, will sooner or later exhibit those details of form and of function which characterize the species, the race, even the family to which it and its relatives belong. On the other hand it has long been recognized that no son is the exact replica—the carbon copy, as Dr. Crew expressively puts it—of his father. *Variation*, or deviation from the average of the stock, is universal.

To be acceptable, any hypotheses of heredity must account for all the main facts of the general likeness of parent and offspring.

In particular:

1. *Variations* occur in the offspring, i.e. characters that are not exhibited in the same degree by the parent.

2. *Specific similarities* occur in the offspring, i.e. characters that occur in one or both parents.

3. Characters may occur in the offspring that do not occur in either parent, but that did occur in a grandparent, or in some more remote progenitor.

4. Characters acquired by a parent in the course of his or her life, as the result of apparent interaction with the environment, *seem in some cases* to reappear in any offspring subsequently born. (This has given rise to great controversy.)

For at least two centuries the zygote (the fertilized ovum) has been looked upon as containing in *some* way the physical basis of the new organism, and during the last fifty years it has become more and more certain that in the zygote there must be something which predetermines the future individual's structural, functional, and even mental, characteristics. There is now, in fact, a complete consensus of opinion that in the zygote is to be found the whole secret of heredity. Although each of the two parents contributes only a single cell so minute as to be far beyond the limits of the unaided eye, yet it is now universally believed that the two cells united in the zygote is *the only material link between the two generations*, and that across this extraordinarily narrow bridge everything organic which any generation can receive from its predecessor must pass. In some form or another the zygote must contain the innumerable factors—whatever physical form these may happen to have—which bring about the build of the child on the model of the parent. Is the child to have blue eyes? then the determining factor must already be in the zygote. Is the child to have curly hair? then the determining factor must already be in the zygote. And so generally.

As the result of countless experiments, the *chromosomes* are now regarded as the only identifiable cell-organs which, by their observed behaviour, can possibly satisfy the conditions of hereditary transmission.

Since there are equal chromosome contributions from the two parents, since there is a random assortment at maturation, since there is a random recombination in fertilization, since, as we shall see later, there is a possibility of an inner reorganization of each chromosome through its most intimate association with another of identical structure but different content, it must logically follow that an almost infinite range of new combinations of characteristics is possible. The chromosome mechanism can apparently supply all the variations upon which the forces of selection can operate.

Since the inner structure of the chromosome is really

beyond the limits of the microscope, the various hypotheses concerning it are necessarily extremely speculative, but that the chromosomes are in some way actually responsible for hereditary transmission, there now seems to be no doubt at all. But how?

The number of chromosomes in an animal (or plant) is invariably very much smaller than the number of *characters* or *characteristics* possessed by the organism. If then the chromosomes are the mechanism of transmission, each chromosome must, in some way, carry the determining factors of many characteristics, and all those present in any single chromosome will be transmitted as a group. This seems to be borne out by experimental evidence, and the characteristics forming such a group are described as *linked*. Each chromosome, then, seems to be a group of elementary units, and it is these units which have been named *genes*. The chromosomes may be looked upon as linearly arranged strings of genes.

When the zygote is formed from the two parent cells, homologous chromosomes seem to pair, to join, to twist round each other, to disjoin, in short, " to play the game of giddy goats ". If it be assumed that in this little game there is an interchange of homologous genes, if in short, there is a reassortment of the genes in the playful pairs of homologous chromosomes, the possible new variations of the characteristics of the two parents that may appear in the child may be almost unlimited. Fig. 56 shows two homologous chromosomes with their hypothetical analogous genes shown by capital and small letters of the alphabet respectively. The interchange of genes is seen in (v). *If the existence of genes be granted*, a complete and acceptable hypothesis of the transmission of innumerable hereditary factors becomes possible.

But about these homologues and analogues hardly anything is really known. We should probably be on much safer ground if all the genes of a given cell were considered to be sorted out at random.

The reader who remembers from his school days some-

thing about Permutations and Combinations will be able to verify for himself that in a four-handed deal in a bridge game, with a pack of 52 cards, there are nearly 650 thousand million possible different hands of 13 cards each Now in each of the (approximately) thousand billion cells which make up a man's body there are 48 chromosomes, and in each chromosome there must certainly be, at the very least, 100 genes,

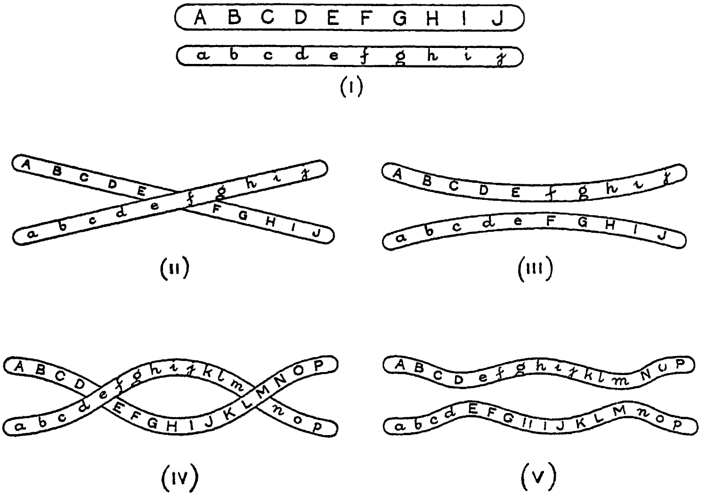

Fig 56.—The junction and disjunction of chromosomes

so that in any zygote there must be, at least, 4800 genes. If then the 4800 genes were dealt out in 48's at random, as the cards were, the number of possible resulting different individual human beings would be so large as to be beyond our comprehension.

The genes, then, are imagined to be the causal agencies in the development of the characters which are represented by differences in the morphologies of the mating parents.

Do they exist? They certainly exist in the brains of many distinguished biologists, but whether they have an objective existence it is absolutely impossible to say. The inferences

drawn from the chromosome linking seen under the microscope do not always seem to be justified. Regarded as an hypothesis it is certainly ingenious. As purely hypothetical entities they are useful.

8. Evolution

Lamarck (1744–1829), a native of Normandy, made the study of plants and animals his life work. Influenced by Buffon, he became an evolutionist. He believed that if all species of animals, existing and extinct, were known, they might be arranged in a long chain, any one link of which would be virtually indistinguishable from its immediate neighbours on either side. The oyster would be there, so would the bee, so would the frog, so would the eagle, so would the whale, so would the fox-terrier, so would man himself though right at the very end. The gaps actually existing in such a chain he ascribed to the destruction of the intermediate links, and he hoped that these gaps would eventually be filled in by palæontological discovery. It was part of Lamarck's scheme that the animal and plant world must have had a common ancestor and that divergence must have taken place at some stage or stages. To Lamarck it seemed impossible that species should be permanently fixed. He thought that there must be some agent acting to produce variations from the original type, and this agent he believed to be *environment*. The essence of Lamarckism is the idea of a new *need* leading to a new *effort* which results in *individual modification*; the need originates and sustains a new movement, and eventually there is a modification of structure. The new need is the result of changed surroundings, a changed "environment". This term "need" implies a recognition of some kind of *sentience* in the creature, which therefore must be the basic cause of evolution. The new character thus "acquired" by the parent is transmitted to the offspring. "Acquired characters" are common enough: the

blacksmith's muscular arm is an instance; and they may persist after the inducing conditions have ceased to operate. *But are they transmitted to the offspring?* The experimental facts which seem to suggest that they are transmitted do not convince all biologists: Professor **E. W. MacBride** vigorously maintains the affirmative, Professor **T. H. Morgan** the negative.

Charles Robert Darwin (1809–82) is the man above all others whose name is associated with that view of the succession of living things which is summed up in the words, *Organic Evolution.* He accumulated great stores of biological facts, and a comparison of these caused him to ponder over theories of evolution. In 1859 his great work, *The Origin of Species*, was published, it expounded the doctrine of what is now commonly called "Darwinism". Twelve years later *The Descent of Man* appeared, which in some respects excited still more attention than the earlier and greater work by reason of its searching inquiry into man's ancestry.

Darwin had a veritable passion for facts: "It is a golden rule," he said, "which I try to follow, to put every fact which is opposed to one's preconceived opinion in the strongest light." "I have steadily endeavoured to keep my mind free, so as to give up any hypothesis, however much beloved, as soon as facts are shown to be opposed to it." He attributed the success of his work to "the love of science, unbounded patience in long reflecting over any subject, industry in observing and collecting facts, and a fair share of invention as well as of common sense."

The Darwinian theory accepted the Lamarckian view that all species, including man, are descended from other species, but it also enunciated, in the light of a vast number of biological facts, *the law of natural selection.* Those organic beings which vary, however slightly, in a manner profitable to themselves have the best chance of surviving, and therefore of being "naturally selected". The less improved forms of life become extinct, for natural selection leads to "the survival of the fittest".

All biologists accept the general theory of evolution, but they are divided in opinion as to the means by which it has been brought about. Some follow Darwin, and stress natural selection; others follow Lamarck who emphasized the effect of use and disuse or habit in species-formation and its hereditary transmission.

Since organic evolution is a process which requires for even its partial accomplishment many millions of years, *direct* evidence is unobtainable. All the evidence is indirect. The main facts may be placed under three heads:

1. *Facts from Systematic Biology.*—Morphological comparisons have been made of existing allied *species*, and the accumulated facts are now so overwhelming that it seems almost irrational to question the main principle of evolution any longer. Like species are grouped into a *genus*, like genera into a *family*, like families into an *order*, like orders into a *class*, and like classes into a *phylum*. A phylum includes all the organisms with a recognizable similarity in their general plan of structure, a similarity which on the theory of evolution indicates that all the organisms within the phylum are descended from a common ancestor. Thus all animals, man included, with segmented backbones belong to the phylum *vertebrata*. A species consists of a series of individuals resembling each other closely, apart from distinctions of age and sex. The animals of any species freely interbreed with one another and produce fertile offspring. Animals of different species breed with difficulty if at all, and only produce sterile hybrids. The question of evolution really resolves itself into the inquiry: *how did the distinct species come into being?* The intermediate grades of classification—genera, families, orders, and classes—are little more than convenient arbitrary collections of species, with limits varying according to the predilections of different naturalists. When Darwin called his book *The Origin of Species*, he went to the root of the matter. The species and the phylum are the two groups of fundamental importance.

It is, however, common knowledge that every large and

wide-ranging species is divided into local *races* or *varieties*, differing from one another in such minor points as colour of skin, hair or feathers, size, density of fur, or length of limbs. Different varieties of dogs, for instance, are familiar to everybody. The varieties of races of a species interbreed freely. But it is often virtually impossible to decide whether two different animals belong to the same or to different species The limits of species are mostly matters of surmise. Sterility is a rather uncertain factor on which to base a decision, as sterility is probably a by-product of increasing difference of constitution. There seems to be every gradation between a race and a species, and as races owe their differences to the different effects of their surroundings, the distinction of species may perhaps be assumed to be due to the long-continued and deeply ingrained influence of different surroundings.

2. *Facts from Embryology.*—The main facts appear in connexion with considerations of ontogeny and phylogeny. These we have already touched upon.

3. *Facts from Palæontology.*—In order to have been entombed and to have become a fossil, an animal or plant must have (1) possessed a skeleton, and (2) been covered up by a deposit. Sometimes the entire original organism is found, e.g. the woolly rhinoceros and the mammoth, frozen in mud and ice; whole insects have been found in fossil resin (amber). Sometimes the skeleton alone is found, the organic matter being lost, as in certain shells in the pliocene beds. Sometimes the original matter has been carbonized, as in some animals and plants with chitinous skeletons, such as graptolites. Sometimes only a mould of the skeleton remains, the skeleton having been carried off by water charged with carbon dioxide. Sometimes there has been petrifaction; the original material has been replaced by another material. Sometimes mere imprints alone survive.

By the study of the stratigraphical succession of fossil forms the phylogeny (race-history) of many animals can be traced with considerable certainty. Progress from one

geological system to another from below is obvious. It is often easy to note the time of appearance of each great group; the Mezosoic mammals, for instance, are all marsupials, and not until Tertiary times do placentals appear; none but animals without a backbone have ever been found in the oldest fossiliferous rocks; fishes obviously flourished long before any lung-breathing backboned animals; the cold-blooded amphibians and reptiles appear, successively, before the warm-blooded birds and mammals; man appears at the end. Linkage forms may often be noted: reptile-like birds, bird-like reptiles, amphibians with affinities to fish, fish with affinities to the amphibians, tapirs with affinities to horses, forms intermediate between camels and llamas; and so on. The palæontologist is thus able to "rough out" ancestral lines. He cannot do more, for palæontological records are very incomplete. Only in a few cases has he been able to discover something like a perfect record of the evolutionary changes that have taken place. The horse is best known. The story of the evolution of the horse has been plainly told in the famous Cañon of Colorado, and thanks to the work of Osborn and his colleagues, we now know of over 260 fossil species lying on or near the line of descent of the modern horse and its living relatives from a tiny animal with four toes (*Eohippus*), not much larger than a fox-terrier, to the modern horse (*Equus*) with only one toe, though the remains of two other toes are still just visible when we examine the bones of the foot in a skeleton. At each step there are gains and losses of characters. The evolution has taken many millions of years from Eohippus to the present day. It is reasonable to infer that this particular line of evolution resulted from the environment demanding from the horse increased running power: the legs were lengthened, the number of toes was reduced, and serviceable well-formed hoofs were developed. Parallel modifications of the teeth were also effected. The horse developed means (1) to *run away* from his enemies (man was the chief one: he was developing at the same time), and (2) to *browse* over vast

plains. The study of such a series of related types seems to compel us not only to adopt the hypothesis of evolution but also to feel that any other hypothesis would be unreasonable.

The visitor to New York who actually sees in the museum there the collection of fossil specimens will possibly be driven to accept the hypothesis of the evolution of the horse forthwith. The evidence seems to be overwhelming. In short, the accumulated facts of animal ancestry enable the biologist to construct a hypothetical genealogical tree. About the first half of the tree there is not much doubt. We begin with the microscopic single-celled animal (the amœba is an example familiar to the schoolboy) and work our way upwards through the microscopic many-celled animal (the fresh-water hydra is an example, also familiar to the schoolboy), and onwards through the starfish, the shell fish, the worms, the lobsters, the spiders, and the insects. Then there is a tremendous leap forwards to the vertebrates, but the nature of the bridge connecting them with all the life-forms which preceded them (i.e. the invertebrates) is very uncertain. Once we have arrived at the vertebrates, however, there is room for certainty again. The evolutionary advance from the fish, through the amphibians, the reptiles, to the birds and mammals, probably took hundreds of millions of years Eventually man was evolved, perhaps a million years back.

The evolutionary hypothesis is not without its difficulties. For instance, time does not *always* bring about change. The general characters of dragon-flies have persisted ever since the Carboniferous period; the common lamp-shell (*Lingula*) possesses almost the identical shell now that its ancestors did in Cambrian times, say, 500,000,000 years ago. The limpet (*Patella*), so familiar on our shores, has been the silent changeless watcher of the evolution of other animals ever since Silurian times, say, 300,000,000 years ago. Again: there is hardly any evidence of the actual origin of the great Phyla: most of them seem to have appeared very suddenly. As for plants, transitional forms are practically unknown.

How was evolution brought about? By natural selection,

as the Darwinians think? or by the inheritance of acquired characters, as the Lamarckians think? With precisely the same objective facts to go upon, the rival schools have come to different conclusions.

An acquired character is one appearing as the result of the action of the environment, and persisting after the removal of the factors inducing it. Numerous experiments have been carried out in an endeavour to discover whether acquired characters are transmitted, and those of Professor **Heslop Harrison** have certainly produced very striking results, but many biologists are very doubtful if such experiments have extended through a large enough number of generations to justify the conclusions drawn from them. The main question is: are such acquisitions *permanent*? or will they be lost after a time, and will the animals revert to their previous forms?

If all dogs were freed from human control, ran wild, and interbred promiscuously, would there be any differentiated varieties left after, say, 1000 generations? Would they all have reverted to their common ancestral type? If they did so revert, we could hardly say that their acquired characters had been permanent. But if acquired characters are only transitory, how does it come about that there seem to be permanently circumscribed limits between species and species?

If we admit, with the neo-Darwinians, that permanent new genes may arise from time to time within the chromosomes (no matter in what way), a complete and satisfactory hypothesis may be advanced. But the opposing Lamarckian school are almost violent in their opposition. Such a "method of dealing with difficulties seems to us mere indolence of thought".

Opinions differ strongly concerning genes. Some eminent authorities deny their objective existence altogether. Certainly the evidence for their existence is largely inferential; in my opinion entirely so. If they do exist, they serve to explain the facts of *heredity* admirably. But of *evolution*?

How are we to account for the fundamental difference

of opinion between two such eminent men as, say, Professor **MacBride** and (the late) Professor **Haldane**? Both familiar with all the ascertained facts, and both quite capable of weighing up the facts and reasoning from them with logical rigour, why are they driven to such diametrically different conclusions?—in the one case that evolution has been brought about by the inheritance of acquired characters, in the other, by gene-transformation due to natural selection. Does not every man's own knowledge and personal experience unconsciously cause him to attach greater weight to classes of facts which seem best to square with that knowledge and experience, and less weight to facts which seem to be in opposition? Is not human nature built this way?

How do species originate? *We do not know.* The secret yet remains to be discovered. How can we ever experiment adequately? If we could experiment on an existing species for 100,000 generations, we might produce a new species and in the doing of it discover exactly how nature has worked in the past. What is the use of pretending that we know already?

Although, however, we do not yet know how evolution works, we may feel, quite consistently with the opposed opinions of experts, a confidence, which really does not brook questioning that some form of evolution contains the truth.

9. The Nature of Life: Biological Controversy

As we have seen, biological controversy is concerned, in some measure, with the existence or non-existence of genes, and with the Lamarckian and Darwinian hypotheses of evolution. But the controversy which centres round the question of the origin and nature of life is much keener. For one thing, the question is much more fundamental; for another, it is much less concerned with accumulated masses of facts than with opinions and with personal bias.

Our knowledge tells us definitely that every living cell

of every plant and animal is, despite its microscopic size, a perfect physico-chemical laboratory. A living cell is a pushing, pulling, pulsating, stretching, contracting thing, engaged in manufacturing organic molecules of an amazingly complex character. That, we *know*. But is that *all* the cell is? Is it just a piece of mechanism, a mere physico-chemical machine? If so, is it an automaton or is it a directed machine? If directed, what is the nature of the director? And since the whole animal body is made up of cells, is the body itself a mere complex automatic machine, or is it directed? Are our actions and our behaviour the mere results of the working of such a machine? Are our very thoughts machine-made, and if so will the time come when we can measure them up, make up a set of differential equations, and from these forecast our thoughts forty years ahead? Concerning these and kindred things, controversy is apt to be conducted at a high temperature. Both sides always seem to be so sure.

It is a curious fact that fifty years ago the great majority of physicists and chemists were whole-hog mechanists, often pugnacious in their opinions. Present-day physicists and chemists are much more cautious, and the pugnacity is found mostly among the biologists.

(A distinction must be drawn between a *materialist* and a *mechanist*. Many earnest Christians are materialists, e.g. those who believe in the resurrection of the physical body, or in a change of the " substance " of the sacramental elements or in a material heaven. But they are not mechanists. A mechanist denies the existence of the soul, and even the mind he reduces to a nebulosity.* He regards the human body as a piece of mechanism, a machine.)

The French philosopher and mathematician, Descartes,

* But there is much variation in present-day usage All mechanists look upon the universe, including man, as just a complex machine, and believe that the complete study of man may be made by the use of the methods of physical science. But not all materialists admit that they are mechanists, and no Christian would *admit* that he was a materialist, because of the connotation of the term in the older sense. The materialist who assumes that label at the present day asserts that consciousness is just a complex quality of the brain but admits that the laws of physical science are not necessarily valid for the study of the more complex problem of man. The materialist is no longer a "whole-hogger", like the mechanist.

looked upon any living organism, man included, as a self-acting machine, but opposition to this view was strong and general, since it was impossible to imagine a machine which makes, maintains, and repairs itself. The vague idea of controlling "spirits" was then put forward; one spirit controlled the digestion, another the heart and lungs, another the sense-organs. ("Spirits" of hartshorn and "spirits" of salt may still be purchased as well as "spirits" of a less innocuous type!) This idea in its turn gave way to various hypotheses of "vitalism". Stahl, of phlogistic fame, believed that the "soul", acting unconsciously, played the part of a "vital principle" or "vital force"; his hypothesis was that of animism. Later vitalists put forward the idea that the phenomena of life are visible manifestations of a vital force acting as an organizing agency but, unlike the soul, acting blindly; death was simply the disappearance of the vital principle. The hypothesis was held by men so eminent as **Müller, von Baer,** and **Liebig.** Gradually, however, it came to be recognized that the hypothesis really amounted to very little more than a negative protest against a mechanistic physiology, and it was abandoned.

Some sixty years ago there was a return to mechanism. The great **Huxley** looked upon "life" as a mere complicated physico-chemical process, and *no more*, but he failed to put forward a satisfactory conception of the *sort* of process that would explain the characteristic features of life. Then came **Driesch** who proved experimentally that any one of the cells of an early embryo is capable, after being isolated from the rest, of developing into a complete embryo. In explanation of this he put forward the hypothesis that the organism must possess a vital individualizing *entelechy* (a vague term borrowed from Aristotle and connoting energizing rather than energy), which was independent of all conditions of environment and determined the growth of the organism as an organized whole. Driesch was a strong anti-mechanist, but, needless to say, his entelechy has never been tracked down.

When we use the word " life " it is generally without a clear conception of what it implies. But a living organism is certainly a unity, a *unity* of a multitude of factors which are co-ordinated, a unity which ensures the development and maintenance of the organism.

If we say that life is a " co-ordinator ", we are at once suspected of supplying the living organism with some new form of active agency—a new soul, a new vital principle, a new entelechy, call it what we may. It is better to say merely that life co-ordinates, for when life ceases, co-ordination ceases too. What life is *we simply do not know*, and it is useless to try to conceal our ignorance behind an hypothesis. Life defies analysis or any reduction to simpler terms.

But life is not the only thing that remains unexplained. *Mere* life is without ideas. *Mere* life does not imply conscious behaviour. The brain itself may be removed from a frog and the animal still be alive. Conscious behaviour is common to all animals and it is much more than mere blind life. When we come to human beings there is something still further to be explained, viz. personality. What constitutes a man's personality? Psychologists may be able to help us a century hence, but they cannot help us much now; their opinions clash and tend to mutual cancellation. And no wonder, the facts obtainable are, as *facts*, exceedingly obscure.

Are our thoughts, our wishes, our decisions, our emotions, our virtues, and our vices, all traceable to chance assemblages of atoms pushed and pulled into position by physical forces, atoms which are ultimately reducible to charges of electricity? This is the position of the extreme mechanists.

Half a century ago most physicists and chemists were mechanists. Now the majority are profoundly distrustful of mechanism and are hopeful of another and more satisfying philosophy. On the other hand, the biologists are divided. The point at issue between them is, at bottom, the interpretation of " conditioned reflexes ", and to these we must briefly refer.

The brain and the spinal cord form the headquarters of the nervous system, from which are distributed to all parts of the body a multitude of branching threads, the *nerves*. These nerves extend to every muscle and to all parts of the body surface, those attached to the muscles being known as *motor* nerves and those distributed to the skin *sensory* nerves. Teachers of elementary physiology often compare the nervous system to a telephone system, the brain being regarded as the headquarters, the spinal cord as a system of exchanges linked up with the headquarters, and the nerves as the equivalent of message-carrying wires. Ask a pupil to explain why he draws back his hand when he unsuspectingly touches a hot body and he will say that the sensory nerves of the skin convey a message to an exchange in the spinal cord and the exchange at once sends back another message by means of motor nerves ordering the muscle concerned to contract. In point of fact this explanation is about as complete as it can be given in simple language That the sensory nerve conveys a message of some kind to a nerve-centre in the spinal cord and that the nerve centre returns another message through a motor nerve to a muscle, so much we *know*; of the *nature* of the message, that is, of the nervous impulse and the molecular changes in the nerves where they act as carriers, we know practically nothing. Since the whole process involves a forward and backward action of some kind, it is comparable to a light impinging on a mirror and being *reflected*, or to a ball striking the wall of a fives court and being reflected. The physiologist speaks of the nerve process as *reflex* action, or as a *reflex*, and this particular kind of reflex he calls an *unconditioned reflex*. Other common examples are the closing of the eyes when a bright light is suddenly flashed before them, the doctor's " knee-jerk ", the opening of a young bird's bill when touched with food brought by the mother bird. It is characteristic of unconditioned reflexes that they seem to be inborn, and that they do not require to be learned. The term " instinct " is no longer much used; it is supposed to be too vague. We shall see.

Complicated " instincts ", such as nest-building in birds, appear to consist of a series of reflexes. In the lower animals, reflexes seem to be very little modified by experience; a moth will fly into a flame even after singeing its wings. But in higher animals and especially in man, experience has a great effect on reflexes. The celebrated Russian physiologist Pavlov devoted prolonged attention to the salivary reflexes of dogs. Everybody knows that the sight of a bit of appetizing meat will make a dog's mouth water. *At first* this flow of saliva is called forth only by the actual food in the mouth; *later* on it is called forth by the sight and smell of the food or by any signal which habitually precedes the giving of food. Thus the *unconditioned* reflex has become a *conditioned* reflex; the response is the same, but the stimulus is a new one, and the new one has become associated with the original stimulus through experience.

Let a tuning fork emitting 256 vibrations a second (the middle C of the piano) be struck as a signal that the dog's food is ready, and let this be continued for a considerable period. Now let the note be struck but no food provided. Insalivation will take place as before, but with continual repetition of the experiment insalivation will gradually cease.

Suppose the striking of the note is accompanied by an electrical shock to the dog's paw. After a time the striking of the note will itself become a sufficient stimulus for the withdrawal of the paw. The striking of a fork of very slightly higher or lower pitch than the middle C will now similarly lead to the withdrawal of the paw, but this modified stimulus will suffer extinction more quickly than the original C stimulus. This type of experiment obviously provides a means of finding the limits of discrimination; in the case of dogs it is a fraction of a tone. A host of experiments of this and analogous types provide a basis of possible *measurements*, e.g. the *quantity* of saliva secreted, *time* intervals and differences.

Pavlov had a dog to whom he always showed a circular patch of bright light before giving him food, and an elliptical patch before giving him an electric shock. The dog learned

to distinguish clearly between the shapes, wagging his tail delightedly when shown a circle but howling dismally when shown an ellipse. Pavlov then gradually diminished the eccentricity of the ellipse making it more and more nearly resemble a circle. Then came a time when the ellipse looked so nearly like a circle that the dog, already uneasy, entirely failed to discriminate; tail-wagging ceased, howling was incessant. In all such experiments there is clearly a margin of discrimination, and naturally Pavlov asked himself the questions, could these degrees of discrimination be measured? and could any rational inferences be drawn from such measurements?

"The law of conditioned reflexes" may be enunciated in this way: *when the stimulus to an unconditioned reflex has been repeatedly accompanied, or immediately preceded, by some other stimulus, this other stimulus alone will, in time, equally produce the response which was originally called forth by the stimulus to the unconditioned reflex.* Mr. Bertrand Russell says that this law is "the basis of learning, of the understanding of language, of habit, and of practically everything in behaviour that is due to experience."

Biologists are divided into two camps: a minority of mechanists, a majority who are not mechanists. Professor **Lancelot Hogben** is the protagonist of the former, and Professor **J. S. Haldane** (the father of Professor J. B. S. Haldane) was, until his recent death, the leader of the latter.

Professor Hogben seems to be absolutely uncompromising. He seems to be convinced that Pavlov's conditioned reflexes is the future key of everything. He admits that the "law" is not yet reducible to quantitative terms, but urges that that is only a question of time. He believes it is utter folly to try to draw a fundamental distinction between living and non-living matter; they are reducible to the same elements and ultimately will be found reducible to precisely the same laws.

"In the light of Pavlov's work," he says, "the problem of conscious behaviour, or, as we should now say, conditioned behaviour, no longer presents itself to biological inquiry as a domain in which the methods of traditional

physiology must be abandoned in favour of introspective speculation. It becomes the problem of defining how new reflex systems can be built up." * "A new school of psychologists has come into being with the express object of making psychology a physical science, relieving man, the celestial pilgrim, of his burden of soul."†

That "new school" will probably be in very ancient buildings before such relief is obtained.

Again: "In the light of Pavlov's work we can now envisage the possibility that the methods of physical science will one day claim the whole field of what may properly be called knowledge If I am right in cherishing such an opinion, it would thus appear that the investigation of the conditioned reflex initiates a new epoch in biology, pregnant with more far-reaching implications than the revolutionary speculations of the nineteenth century. The fact that no reference to the conditioned reflex is contained in Dr. Haldane's Gifford Lectures may in part account for the fact that he can so easily dispose of the mechanistic position. The modern mechanist does not say that thought and love and heroism do not exist. He says, show me behaviour to which you apply the adjectives thoughtful or loving or heroic, and we will, one fine day, endeavour to arrive at predictable conclusions with reference to it by following the only method of inquiry which we have learned by experience to trust. When Dr. Haldane goes out of his way to dispose of the puerile formula that thought is a secretion of the brain as bile is a secretion of the liver, and does so, I gather, under the impression that mechanists either believe it to mean something or alternatively shut their eyes to the major problems of existence, I can only respectfully suggest that he is flogging a dead horse while the living ones are getting out of the vitalistic stables." ‡

"We will, one fine day, endeavour": these words are wholly satisfactory. But is Professor Hogben quite so "neutral" as he claims to be when he flogs Professor Hal-

* *The Nature of Living Matter*, pp. 48–9. † *ibid.*, p. 90. ‡ *ibid.*, pp. 90–1.

dane? Mechanists (materialists, as they were then called) spoke of " thought " as some sort of " secretion of the brain " half a century ago. T. H. Huxley used it in my own hearing; so did his friend Tyndall. " Secretion " was not literally meant of course; it was a mere fashion of speaking, a suggestive metaphor. Those who maintain that thoughts are ultimately derived from things have to use *some* term suggestive of emergence, and whether this is " secreted " or " distilled " does not much matter. The vaguer the term the more easily the mechanist can defend himself.

The late Professor Haldane (he was the world authority on respiration) took the other side. He said:

" From the physical standpoint biological phenomena are indefinitely complex, and for this practical reason alone are incapable of being formulated in physical form, and thus remain unintelligible; but they are also unintelligible in the deeper sense that they are essentially undefinable physically. From the biological standpoint, however, they are intelligible through the perception that they are maintained or reproduced in a characteristic manner. Life is from its very nature incapable of being described or understood in terms of mere physical conceptions. Biological explanation or description is essentially different from physical explanation or description, and aims at the discovery by observation and experiment, of specific maintained relationships in phenomena, the existence of which makes prediction possible."

Again: " It is not that physical description of conscious behaviour is not satisfactory up to a certain point but that it is totally inadequate to furnish any intelligible description of conscious behaviour as a whole. . . . We cannot dispense with the conception of active personality which is present in all the phenomena studied. In our bodily structures, no less than in our environments, we are aware of personality, and any mere physical interpretation of them is quite inadequate."*

These two distinguished men, Professor Hogben and Professor Haldane were thoroughly familiar with all the

* *The Philosophy of a Biologist.*

available facts. Why, then, did they come to diametrically opposite conclusions? Can it be that the one is a machine so perfectly made and adjusted that in its working it is infallible, and that the other was something more (or less) than a machine whose reflexes were so untidily tied up that they occasionally led him astray?

When during the course of evolution life first appeared, it was a novelty: when conscious behaviour first appeared, that was a novelty; when man first appeared, he was a novelty. But what is a novelty? A little cold logic from Oxford may help us.

"The belief that 'evolution' in the sense of progress would continue has become an *act of faith*, which the past could engender but could not prove. Logically it reduces to a *probability*, the strength of which it is hard to estimate, but which will loom large only in the eye of faith. It is plain also that we are *not* entitled to assert the reality of any universal evolution as a 'law' of nature. We have to be constantly on our guard against the insidious temptation of conceiving 'progress' circularly, as whatever evolution tends to. This seems an easy way of establishing the reality of 'progress' but it is merely verbal and utterly fallacious."

Again: "Real novelties always have a hard time at first. Among their just grievances, the fact that officially they are always denied existence ranks high. But they might complain nearly as bitterly of the attempt to dismiss their claims by applying to them the word 'emergence'. For 'emergence' is in no wise an explanation of the occurrence of novelties: it only records their occurrence, and is hardly even a candid recognition thereof. For it is apt to be rather the vehicle for an ambiguous insinuation that the alleged novelties are not truly new but have long been lurking obscurely in the dark and waiting for an opportunity to break forth into the light of day. Thus etymologically, 'emergence' has the same sort of dishonesty as 'evolution'."*

* F. C. S. Schiller, *Must Philosophers Disagree?* pp. 205, 209.

Do mechanists "emerge"? or are they "real novelties"?

Although the nature of life is entirely unknown, we are compelled to think of a living body as some sort of organization of co-ordinated activities. Is it possible to track down specific co-ordinating agents of any kind? That the nervous system is chiefly concerned with co-ordination seems certain, but there are apparently co-ordinations of a more specific kind effected by the "hormones", substances manufactured in the ductless glands,* discharged directly into the bloodstream, and carried to those parts of the body where they come into action. These secretions are known to be amazingly potent though extraordinarily small in amount, and, although investigators have by no means completely tracked them down yet, they seem to appear when they are wanted and to disappear when they are not. They do not seem to be converted into other substances but to act as messengers, co-ordinators, organizers, body catalysts. But hormones, like enzymes and vitamins, are very elusive, and the biochemist is not yet completely their master. Thyroxin from the thyroid gland in the neck is one, insulin from the pancreas is another, pituitrin from the pituitary gland in the brain is a third. That all the hormones are directors of some kind is highly probable, but when it is gravely suggested that the zygote (the fertilized cell) is directed by a hormone which in some way decides whether it shall develop into a bee or a bird or a rabbit or a man (the zygotes of all these are admittedly indistinguishable), is it not making a rather large demand on our gullibility? But even granting that a hormone is such a director, what is it, in turn, that directs the hormone? A hormone of higher rank? Do we get back at last to just a pulsating complex molecule? And what initiates the pulsation of the molecule? Where is the regress to end? What sort of a thing is the physico-chemical organizer in chief?

It simply will not do. We seem compelled to postulate the existence of matter in two states, the living and the non-

* As distinguished from glands like the liver and the salivary glands which have *ducts* for carrying away the fluid secretions.

living. If the existence of life be granted as just an inexplicable elementary fact, no far-fetched ingenuity for explaining it away will any longer be necessary. This does not mean that the secret of life may not some day reveal itself. Many distinguished bio-chemists and geneticists are at work, and far-reaching discoveries are constantly being made. But far-fetched hypotheses are sometimes allowed to dwarf these discoveries, especially by the man in the street, whose knowledge and understanding of science is necessarily superficial.

As a biological worker Professor Hogben adopts the procedure and principles of Scientific Method. He says for instance:

"The mechanist never legitimately claimed more than the right to investigate the properties of living matter in its simpler manifestations by those methods whose success had been justified in the domain of physics and chemistry. If the mechanist ventured to speculate beyond those limits, he transgressed his terms of reference." *

"I do not assert that all aspects of conscious behaviour will eventually be explained in terms of Pavlov's conditioned reflexes. I do affirm that Pavlov has successfully applied the methods of traditional physiology to the study of processes presumably included in Dr. Haldane's definition of conscious behaviour"†

"How far it is possible to reduce the interpretation of behaviour to purely physico-chemical hypotheses, we have no means of predicting. At present we can foresee no limit to progress in that direction. The significant issue is not the completeness of the mechanistic solution, but whether there exists any definable method of arriving at a more complete solution than the mechanistic outlook permits."‡

With such views we cannot but cordially agree.

We may, however, quote a few more of Professor Hogben's opinions:

"The modern physiology of the conditioned reflex has undermined the distinction between reflex and voluntary

* *op cit* p. 49. † p. 54. ‡ p. 1.

behaviour." "As a concept of biology *Mind* is replaced by *Behaviour*." "Modern biology claims to interpret the characteristics of conscious behaviour as properties of physical objects."*

"A philosopher is a particular kind of organism. Philosophy itself might therefore be regarded as an aspect of the behaviour of a piece of living matter."†

"The belief that a philosophical discussion of the Nature of Life lies beyond the province of the biologist is due to centuries of subservience to a tradition which has identified philosophy with the interests of statesmanship and ecclesiasticism."‡

"It has been customary in the past to assume that the concept of *consciousness* defines a field in which the methods of experimental physiology break down and require to be supplemented by the method of introspection."§

"Modern biological enquiry is disintegrating consciousness into an atomic nexus of reflex arcs."||

Professor Hogben quotes, with approval, Professor Hill:

"Fortunately for physiology several of the generalizations of science appear to be fairly strictly true, even when applied to the living organism. Although such exact experiments are not possible on man, or animals, or plants, as may be made on non-living objects, there is little evidence—indeed, I would be bold and say there is no evidence—that such living creatures can, in any manner or degree, evade the ordinary laws of mechanics, chemistry and physics, the principles of the Conservation of Energy and Mass. . . . There really is *no* evidence that momentum and kinetic energy, that chemical transformations, that electrical and magnetic phenomena, occur in the living body in any manner, or to any extent, which differs from that obtaining in the more readily investigated non-living world." ¶

No. The great majority of scientists now emphatically deny that the living organism is *nothing more* than a mere uncontrolled chemical and physical laboratory.

* *ibid*., p. 1. † p. 11. ‡ p. 15. § p 23 || p. 26. ¶ pp. 107–8.

Professor Hogben concludes his book thus:

"It should occasion no surprise that the new horizon revealed by the growth of biological enquiry now seems contrary to common sense and inconsistent with the language we are accustomed to use in everyday life. Man has existed on this planet for perhaps a matter of 500,000 years. During that period little more than 5000 years have been occupied by the building of civilized society. Of that fraction the main development of the essentially social language of science has been compressed to a very large extent within the last 500 years. We are still the creatures of a tradition of fear, of superstition and of misunderstanding, of childish self-assertion and savage self-submissiveness to magical prohibitions handed down to us from what Professor Levy has aptly called the unsavoury past.

"The majority of men are impatient towards the discipline which science imposes upon us. That impatience is a bulwark of magical beliefs. It has been well said by Trotter: 'In matters that really interest him, man cannot support the suspense of judgment which science so often has to enjoin. He is too anxious to feel certain to have time to know.' Because science does not flatter our self-importance, because science makes stringent demands on our unwillingness to face uncomfortable views about the universe, because patience with the slow advance of science requires the effort of intellectual self-renunciation, human nature, deeply rooted in its unsavoury past, is on the side of vitalistic theories. Social privilege is repelled by the mechanistic outlook because of its ethical impartiality. Age brings its impressive authority to reinforce both human nature and social privilege. When the spirit of intellectual adventure dies and with it the courage to face the austere neutrality of a universe which mocks the self-importance of our individual lives, when the ruthlessness of death and decay threatens to rob us of the few circumstances propitious to personal comfort, when the limitations of our greatest achievements are no longer assuaged by the prospect of renewed opportunities, it becomes all too easy to find the

formula which provides a compromise for the conflicting claims of magic and science. Perhaps the time will come when our knowledge of the Nature of Life will provide an explanation of this circumstance." *

But can Professor Hogben himself "support suspense of judgment"? Let it be granted that conditioned reflexes will yield a satisfactory "explanation" of Sensation, Attention, and Memory; the explanation will be only hypothetical and may therefore quite possibly be superseded. But how is he justified in making the tremendous leap forward from this very tentative preliminary work of Pavlov's to the assumption that we are, without any sort of doubt, on the way to a complete and final physico-chemico-electrical explanation of life, consciousness, and everything else concerning the human being. Such a leap is a leap into deep waters indeed. In the Rockefeller Institute of American research a piece of chicken heart has been kept alive since 1912, and unless one of the attendants oversleeps himself one morning, it may well be kept alive for another century; and many other remarkable experiments have been performed by physiologists and biologists with nerves, with muscles, and with live animals such as tadpoles. The accumulation of facts is proceeding apace and the outlook is very hopeful, but we certainly are still profoundly ignorant of the real nature of either life, consciousness, or personality. The mechanist *may* prove to be right, but it will be many a long year before we shall know. And he has but a very small following at present.

When on 20th May, 1936, at the Conway Memorial Hall, we listened to Professor Hogben delivering his lecture *The Retreat from Reason*, we utterly failed to recognize him as the thing he seems to claim to be—a piece of mechanism. Strive as we might we could not understand how the sentiments he expressed so admirably and with such remorseless logic could be disintegrated into "an atomic nexus of reflex arcs". We tried to initiate the reverse process of integrating purely elementary reflexes, beginning with those that were re-

* *ibid*, pp. 315–16.

sponsible for the succession of sounds that came from the vocal cords, but when we went a step beyond and tried to discover the reflexes by which the separate words could be integrated into thoughts we were baffled beyond all telling. But we came away with the feeling that the machine was one of amazing efficiency, perfectly wound up and perfectly tuned. We knew it was not respectable to think of his sentiments as a "secretion", and we therefore attempted to think of them as having been etherialized in some way, for we knew we had to think of them as laboratory products of some kind. But success would not come. A listener sitting next to me remarked, "I wonder why they gave Professor Hogben the name of Lancelot? If he really were brought up in the court of a water-fairy, the Lady of the Lake probably found his boyish reflexes full of interesting daily surprises." And that listener was a rather serious-minded man!

10. The Region between Physiology and Psychology

The region between Physiology and Psychology is still a region of mist and of scepticism, but new attempts are now being made to explore it. As long ago as 1929, Berger claimed that in the human head he had discovered differences in electrical potential of obviously cerebral origin, and that he had then succeeded in leading off the currents for examination. In 1935, Professor Adrian addressed the Neural Section of the Royal Society of Medicine, taking as his subject "The Electrical Activity of the Cortex", and he forecast that the study of electro-encephalography would prove to be of use to the clinician.

In the latest edition of his book on Applied Physiology, that distinguished physiologist, Professor Samson Wright, refers to Berger's work. "When electrodes are applied to the human head, a remarkable electrical effect can be detected which consists of a rhythmic oscillation of potential with a frequency of about ten per second, which develops under

certain conditions when the eyes are closed. It can be proved that they are due to a synchronized rhythmic discharge, which takes place under appropriate conditions, from the neurons of the occipital region of the cortex. They are not due to the activity of the muscles of the eyes or head or to retinal action currents. The waves are largest when needle electrodes are pushed through the scalp in the region where the skull has been removed, strongly suggesting that they arise in the brain. They are usually well-marked when one of the electrodes is placed on the surface over the occipital region."

Mr. W. Grey Walter, of the Central Pathological Laboratory, London County Mental Hospitals, has, for a considerable period, been researching in the subject, and the paper he read before the Royal Society of Medicine in March, 1937, *The Electro-Encephalogram in Cases of Cerebral Tumour* (it is printed in Vol. XXX of the Society's Proceedings) gives a very clear and detailed account of the whole subject. He reminds us that the term "electro-encephalogram" (ἐγ-κέφăλος = brain, γράμμα = graph) was coined by Berger to describe the wave-record of charges of electric potential associated with the brain. The strength of the currents led off from the brain is extremely minute, anything between five-millionths and one-thousandth of a volt. For recording purposes they have to be enormously amplified, and this is done by ordinary thermionic valves. The amplified potentials are led to cathode-ray oscillographs, the resulting graphs being of the ordinary wave-type though very complex and requiring expert analysis.

Four types of waves have been clearly differentiated, α, β, γ, and δ. The α-waves are the best-known, but they are usually only to be found when the subject's eyes are closed and the mind at rest; if the mind is concentrating on some problem, they are absent. The β-waves are most marked in subjects who are depressed or irritable, or in subjects with raised eye-brows or wrinkled foreheads. In short, each type tells its own particular story.

The effect of drugs and anæsthetics is under active investigation.

Any sort of abnormal cerebral activity shows itself at once in the waves. A cerebral tumour, for instance, can be localized at once—a tremendous advantage to the clinician. The on-coming of a so-called brain-storm, as in epilepsy, can be readily detected—another great advantage.

Brain troubles both of a physical nature and of a mental nature seem, somehow, to reveal themselves in the waves, and they can then often be localized. There is a definite correlation between the type of wave and the source of trouble. The electro-encephalogram seems to be a great store-house of information, given us in a form which at present admits of very imperfect interpretation. We must be content to await the results of further research.

It will be a great temptation to enterprising journalists to turn this new knowledge to professional account.—We *know* that the brain gives out electrical waves. So does a wireless transmitter, and sends them to the other end of the earth. Very well, *now* we know the secret of telepathy: it is a new sort of wireless, brain-waves directed from one person to another perhaps 10,000 miles away. How simple it all is, and how wonderful are scientific explanations!—Meanwhile research-workers at the mental hospitals are pushing on with their investigations.

Although it is true that certain types of mental trouble can now be definitely traced to some sort of abnormal activity in a particular part of the brain, *how* and *why* that particular trouble can be brought about (if it is so brought about) by cerebral electrical disturbances *we do not know*. The mist enshrouding the region between physiology and psychology is as impenetrable as ever. All that the new work has done in this region so far is to establish the fact that there are *correlations*.—We shall return to psychology in the next chapter.

11. Scientific Obsession

To me it is a source of much puzzlement to know that there are still a few distinguished men of science who can bring themselves to believe that the universe we know and all that therein is came into existence by chance, developed into its present state by chance, and produced intelligent human beings by chance. They seem to be obsessed with the idea that it is a sign of intellectual decrepitude to suggest that, behind it all, there must be some organized plan, some purpose. And they seem to have a hankering to reduce all things to *one*. To admit that mind and matter (as we may still call them) are separate and distinct entities is intellectual decrepitude indeed. Dualism? nonsense. Monism? of course. They have come to like being known as monists, mechanists preferably, idealists if need be. But dualists? no: dualism is as dead as the last Stuart queen.

All men of science are familiar with thousands of facts in the *in*organic world that point to a wonderful scheme of organization and co-ordination; and to account for these things they postulate atoms, forces, waves, and what not, and they advance explanatory hypotheses by the score. But a few of them are in such dire terror of cutting their fingers with Occam's razor that they refuse to hypothecate the existence of just one more elementary thing, viz. *life*. They invent, say, an atom, which is no longer an inert thing but a wonderfully organized complex system of electrons in perpetual motion, but they deny, again because of the razor, that behind the invention there is some form of *intelligence*.

Like Newton we are healthily shy of new hypotheses, but science is already full of them. Why should we be afraid of just one more, an hypothesis of co-ordination? We need not invent a demon as we did when we invented the old "force" of gravitation, but we are bound, somehow, to admit the *fact* of co-ordination and organization.

This would not mean that we were advancing the claim to *understand* the nature of the activity underlying the co-ordination and organization. The *nature* of such activity, science emphatically does not know.

What a vast amount of amazingly successful work science has already *done*. But how little science *knows*! It does not know the cause of a common cold. It does not even know how sap rises to the top of a tall tree. How it is riddled with hypotheses, and how few of these will survive! But science is still a babe: serious science is little more than a single century old What will it know a *hundred* centuries hence, a *thousand* centuries hence? We have not even learned to cross interplanetary space yet, but now that the Relativists have abolished gravitation, and turned dynamics into geometry, we may perhaps feel hopeful of a regular Martian service soon; but what a long time the astronomer-mathematicians are taking to straighten out the intervening tangled " world-lines ".

Most men of science are workers and are pushing on with their researches. They are content to search for new facts, to scrap old hypotheses if the new facts will not fit into them, and to devise a new temporary working scheme into which both old facts and new can be given a harmonious setting. But there are a few men of science who indulge in easy-chair speculation and sometimes become obstinate dogmatists.

All scientific theory is purely provisional. The layman should never accept a scientific hypothesis as if it represented objective facts. An hypothesis is just a sort of framework into which a group of facts may be conveniently arranged temporarily. Any hypothesis which is put forward as a faithful reflector of some part of nature is dishonest. Scientific hypotheses being always subject to review can never be regarded as belonging to any sort of final creed. Scientific dogmatism is immoral. Scientific *belief* may come as the result of the coercion due to the accumulated force of many facts, but that belief should never be allowed to become an

obsession. Only now and then is the belief ever likely to be finally substantiated, and to be fully representative of truth.

Science does not yet know, but it is always searching, and is always hopeful of finding

Every working scientist naturally has views of his own, views which he forms by the sheer pressure of those facts with which he is most intimately acquainted; and he may rightly hold those views tenaciously. It is only when he scoffs at those of his fellow-workers whose views happen to be in opposition to his, that the world grows impatient with him. For the world is fully aware that, after all, he really does *not know*.

BOOKS FOR REFERENCE:

1. *The Endless Quest: 3000 years of science*, F W. Westaway. (Readers who are interested in the technical details of the chapter may usefully refer to this book.)
2. *Scientific Method: its philosophical basis and its modes of application*, F. W. Westaway.
3. *The Philosophy of a Biologist*, J. S. Haldane.
4. *The Nature of Living Matter*, Lancelot Hogben.
5. *Lowell Lectures*, A. V. Hill.
6. *Lectures on Conditioned Reflexes*, I. P. Pavlov, trs. W. H. Gantt.
7. *Pavlov and His School*, Y. P. Frolov.
8. *The New Conceptions of Matter*, C. G. Darwin.
9. *The Universe in the Light of Modern Physics*, Max Planck, trs. W. H. Johnston.

Books 3 and 4 should be carefully read and compared.

CHAPTER X

Philosophy: Knowledge or Speculation?

1. From Science to Philosophy

That the uninstructed plain man should rely implicitly on the evidence of his senses is a perfectly natural thing. How often we have heard him say, "Cannot I trust my own eyes?" He sees the sun in its daily journey from east to west across the sky, and, like the ancient astronomers, he makes the assumption that the sun goes round the earth. To him the assumption involves no element of doubt; to him it is not an hypothesis, it is a fact. When it is pointed out to him that the alternative hypothesis of the earth going round the sun provides a simpler explanation of the celestial motions and is more consistent with ascertained facts, he is puzzled, and his respect for authority may make him feel that his senses, at all events his sense of sight, may sometimes deceive him. If he becomes a student of Science he finds that many of his established notions are hopelessly wrong. In thinking about ordinary material things, for instance, he had always thought that quite independently of their relation to himself they were visible and coloured. The evidence of his senses he soon learns to accept with greater caution, and he comes to understand that, so far as Science distinguishes reality and appearance, its criterion is not sense-perception alone, but consistency with an elaborate and complex system of more or less definitely established facts which embody the combined results of many perceptions and inferences. Science has continually to explain to uninstructed common

sense that what really happens is often something quite different from what appears to happen.

The chemist performs a number of quantitative experiments, examines his results, and detects amongst them certain common quantitative relations, sums up these constant relations as "generalizations", and so establishes quantitative "laws" which constitute important principles of chemistry, and form the basis of the theory of the subject. The justification of these laws is a great number of definitely established facts. They involve no assumption, no hypotheses, save that of the great induction of the uniformity of nature.

The chemist now seeks for an "explanation" of these laws and for this purpose he brings forward the hypotheses of Dalton and Avogadro. But these hypotheses are *assumptions*; they are constructions of the chemist's mind; they may or may not correspond to objective fact. In making these assumptions the chemist is trying to get behind his observed facts, behind his phenomena, in order to discover the hidden secrets there. In doing this he is passing over the borderline between the domain of Science and the domain of Philosophy.

Such assumptions often prove to be wrong. Again and again in the history of Science, one hypothesis has been discarded in favour of another. But each hypothesis served at the time to cover all the facts then known and to link them up. Sometimes a new hypothesis has superseded an old one because the latter would not cover new facts, and was therefore obviously wrong; sometimes an old hypothesis has been discarded because seen to be held on insufficient grounds; sometimes an old hypothesis has been reduced to a simpler form: the mind always prefers a simple explanation to an elaborate one. Around and beneath the more settled portions of Physical Science, in the region where knowledge is growing in range and depth, there is constant conflict and controversy as to the truth of new conclusions, for the controversy centres round assumptions which are unproved, and often seem unprovable. All theories of Science are necessarily infected with error.

It has been said that the truths of Philosophy bear the same relation to the higher truths of Natural Science as each of these bears to the lower truths of Natural Science. But the term truth is hard to define, and it would be safer to say that just as each widest generalization of Science embraces and consolidates the narrower generalizations of its own division, so the generalizations of Philosophy embrace and consolidate the widest generalizations of Science. It has, however, to be borne in mind that the main concern of Science is with phenomena, because the investigations of Science yield mainly phenomenal knowledge. Philosophy aims at a knowledge of concealed realities behind phenomena. There is, however, a great deal of common ground between Science and Philosophy, and the purely speculative side of Science properly belongs to Philosophy. Neither a philosopher unversed in Science nor a scientist unversed in Philosophy can claim to be an authority in his own subject.

2. What Philosophy Is

Plato, the greatest of the Greek philosophers and perhaps the greatest philosopher the world has ever known, defined a philosopher as one who sought to know the inner nature of the reality of things, in contrast with the man who is content with mere appearances. But Plato made little or no attempt to differentiate between logic, psychology, physics and metaphysics, ethics, æsthetics, and the theory of knowledge, and his philosophy was really a medley of all these things, and it included a good deal of mathematics as well; Plato was a mathematician. His brilliant pupil, Aristotle, was a much more methodical man, and it was he who sorted out the medley into separate and distinctive studies. In the broader sense, philosophy, as now understood, subjects to critical analysis the fundamental principles of all departments of systematic thought, mainly from the point of view of examining their validity and the evidence supporting them. We

may refer briefly to three of these departments, viz. logic, psychology, and metaphysics.

Formal **Logic** was both sword and shield to all the scholars of mediæval times, who never dreamt of doubting its efficacy as an offensive and defensive weapon. Their confidence in it was the confidence of a little child in its own mother. A correct chain of deductive reasoning from some original hypothesis dogmatically asserted was quite sufficient to stifle any doubts about strange conclusions; and gradually the opinion became almost universal that the most important truths concerning reality could, by mere thinking, be established with a certainty that no subsequent observation and experiment could shake. And even at the present day there are philosophers who claim that *a priori* reasoning can reveal otherwise undiscoverable secrets about the universe, and that, therefore, reality can be proved to be quite different from what by direct observation it appears to be.

In the light of modern science, great numbers of old *a priori* errors have been refuted, and it is now natural to expect a fallacy in any deduction which appears to contradict facts known to be certain. The fallacy is not usually in the actual chain of reasoning: philosophers do not often make elementary blunders of that kind. It is traceable rather to an untenable major premiss, adopted, perhaps, because of the royal confidence felt in some unexamined intuition, or because of some unsuspected prejudice, political, social, or theological. This major premiss, the original hypothesis adopted, may look plausible enough, but if the consequences which are logically traceable from it are found to violate the first principles of common sense, the hypothesis must, without hesitation, be rejected. A conclusion is by no means necessarily correct because the rules of formal Logic have been exactly observed. The unacceptable conclusions of educated men are far more frequently traceable to false premisses than to false reasoning.

The formal Logic of tradition is merely a logic of con-

sistency. As Mr. Bertrand Russell says: "The trivial nonsense embodied in this tradition is still set in examinations, and is defended as a training in those habits of solemn humbug which are so great a help in later life." Modern Logic is something very different. Its chief business is to examine the validity of premisses, and it deserves the closest attention.

Originally, **Psychology** was practically a branch of Metaphysics, and derived most of its facts (if we may call them facts) from introspection. But in recent years it has torn itself away from Philosophy and has promoted itself to the dignity of a Science, though this self-promotion is not universally approved. Its different schools are, however, engaged in the study of the mind empirically, and they proceed by methods of observation, experiment, and induction, analogous to those used in natural science. But the phenomena of the mind—thoughts, cognitions, judgments, beliefs, the facts with which psychology deals—have still in large measure to be obtained by introspection, not through the senses as in the case of the phenomena of natural science. The difficulties of ascertaining the facts are therefore greater, and psychological interpretation is not always easily distinguished from metaphysical reflection. It is this that makes many intelligent people attach a very sceptical value to the whole subject.

The different schools into which present-day psychologists are divided are opposed, even if not mutually hostile. Two of the schools have developed important techniques. The first is the technique of Dr. Sigmund Freud, whose original purpose was primarily therapeutic, to cure people of the less extreme forms of mental disorder; and in the course of his work he was led to a view of the causation of such troubles. He came to the conclusion that many forms of mental disorder are to be regarded as the consequence of conflict between (i) repressed and unconscious ideas and (ii) conscious thoughts. Psycho-analysis attempts to make the patient fully conscious of the repressed ideas. The subject is

making headway, but, inasmuch as sexual desire is a cardinal factor in psycho-analysis, the technique is likely to be dangerous if practised by those who are not medical experts.

The second school of psychological technique is that of Behaviourism. Its experimental basis is due to Pavlov,* and it has become generally known through Dr. J. B. Watson. The fundamental Behaviourist view is that man has no mental processes different from those of animals; that his actions are automatic responses to stimuli; that thinking is only behaviour; and the idea of any sort of mind or soul is scornfully repudiated. That every phase of consciousness has its counterpart in, and is inseparably connected with, molecular changes in nerve cells is highly probable, but that our thoughts, judgments, and beliefs are *nothing more* than such mere changes is an hypothesis which is incredible.

Whether the Psycho-analysts or the Behaviourists will ever work out an acceptable " science " of psychology remains to be seen. At present the whole subject is a thing of shreds and patches.

Perhaps the greatest advance in the subject is being made by Psycho-therapy, a branch of medicine associated with the names of such distinguished physicians as the late Sir Maurice Craig, Dr. W. Langdon Brown, Regius Professor of Physic in the University of Cambridge, and Dr. William Brown, Wilde Reader in Mental Philosophy at Oxford. Suggestive treatment for neurotic patients seems now to be meeting with marked success.

Many prominent educationists are also engaged in important psychological research, though of a more modest kind than that of the Psycho-analysts or of the Behaviourists.

The Spiritists claim to be doing something, too, but how shadowy those claims! Why do they sometimes assume the title of " Spiritualists "?

Psychology is admittedly still in the nursery, but this is no sort of reflection on the many distinguished nurses who are tending it.

* See the previous chapter.

Metaphysics is wholly unlike any branch of science. It despises experiment. It laboriously digs its knowledge out of the dark recesses of its own soul. It aims at discovering facts concerning matter and mind and their relations which are *beyond* (μετά) such knowledge as is obtainable from, and can be verified by, science. Its method is peculiar to itself; it begins by making *a priori* pronouncements, and, by applying to these the rules of formal Logic, arrives at final conclusions which do not admit of any form of methodical proof or any sort of appeal to experience. Such conclusions, based as they are ultimately upon hypotheses which cannot be verified, are necessarily always uncertain.

Constructive Metaphysics has been called " a form of sophisticated myth-making ", but all down the ages it seems to have had a fascination for intellectually gifted men. " Metaphysics may be the finding of bad reasons for what we believe on instinct, but to find these reasons is no less an instinct." So said Bradley.

We shall return to metaphysics presently.

Ethics, Aesthetics, and **Economics** are sometimes spoken of as sciences, sometimes as branches of philosophy. Strictly speaking, neither term is really applicable to them, for they are not yet represented by generally accepted crystallized bodies of doctrine. Unlike Psychology, however, Ethics and Aesthetics are out of the nursery, though they are still attending school. As for Economics, it steadfastly refuses to be anchored; chameleon-like, it assumes the tinge of any politician who approaches it.

Sometimes **Politics** is solemnly referred to as science or even as philosophy. It will suffice to quote Mr. Bernard Shaw: " democracy is merely the substitution of the incompetent many for the corrupt few "; and again, " there is no sincere public opinion to-day that a man should work for his bread if he can get it for nothing ". Are these principles of political science? or are they dicta of political philosophy?

3. A Modern Philosopher's Opinions concerning his own Subject

Oxford has for centuries been the intellectual headquarters of British philosophy, and one of the best-known of its present-day philosophers is Dr. F. C. S. Schiller. For more than forty years his various works have made a strong appeal to students of the subject, not only for the intrinsic worth of their contents but also because of the exceptional lucidity with which those contents are presented. We may quote from his article in the Aristotelian Society's *Supplementary Volume*, 1933, "Must Philosophers Disagree?" *

"Whenever we take a science as a special department of knowing which from motives of convenience has been marked off for the purpose of inquiry, we find that its chief feature is always that it rests on *abstractions* and *selections*. Just because every science is a 'special science', it selects a special aspect of the whole field of possible inquiry, and cultivates it by special methods suited to its special purpose. But the other side of special attention is rejection and abstraction. Every science ignores and abstracts from whatever is not relevant to its purpose."

"There are big and important aspects of the real which fall without the purview of *every* science, and which can therefore be considered only by philosophy. There is, for example, the great fact of *personality*. This means that every vital process, every feeling, every perception, every reasoning, despite its general likeness to those of other persons, presents individual differences. The actual behaviour of every one is strictly the revelation of an idiosyncrasy.

"Idiosyncrasies, however, appear to be beneath the notice, or beyond the reach, of science. In every science these in-

* Now embodied in his book of the same title. We quote from Chap. I.

dividual or personal differences are ignored in constructing the standardized percipient, thinker, or observer, whose reactions are treated as 'normal'. Similarly, large tracts of actual experience are excluded as 'subjective', in order to focus scientific attention upon the selected and preferred sections which are judged fit to reveal objective reality. Hence the real data, which are truly 'given', all arise in the personal context of an individual soul: they are never the *scientific* 'data' from, and about, which the sciences argue. The latter are always *selected* from the former, and dictated by the interests of each science; moreover, they are usually seen in the glamorous light of whatever interpretative theory happens to be in fashion."

"Thus it is 'objectivity' which is always factitious and fictitious; the selected spheres of interest and operation of the various sciences are really the outcome of highly selective value-judgments. Actual experience is always grouped round a *personal self*. So all *experienced* reality is egocentric, and every self differs more or less from every other."

"After the sciences have done their utmost and told us what the truth is according to their several lights, they leave us with a big unsolved problem, the problem of the Whole. To this problem they can offer no solution, because their whole procedure has been to *dissect* the apparently presented real by selecting such parts as seem to them relevant to the special purpose and interests of each science. So from one point of view the final outcome of the scientific attitude towards the real is, not a cosmos, but a chaos, a congeries of sciences that have selected different aspects of the Whole, studied different 'facts', and departed from the given in different directions. The cosmic jig-saw puzzle has been cut up. Humpty-Dumpty has been effectively dismembered, and just because it is a *special* science, *no* science can presume to put him together again. A new discipline, with a new method and a new aim, is needed to cope with the problem of the Whole."

"Of course it follows at once that Philosophy has no right

to make abstractions. Rather, it must *undo* the arbitrary abstractions the sciences have made, and make good any damage they may have done. Now this applies particularly to the scientific abstraction from personality. Personality cannot be ignored by Philosophy. For it would seem to be the root of the underlying obsessions which render rational discussion so difficult in philosophy. Just as there are persons with whom rational conversation is impossible, because they are obsessed with sex, so among philosophers. The sex-obsession dominates Freud; the mechanical, Watson; while (until recently at any rate) the philosophers deemed ' orthodox ' were so obsessed with the ' Absolute ' that they never noticed how utterly empty and fatal to human knowledge were the explanations given in its name. So personality turns out to be a most important fact, which Philosophy is bound to exalt to a place of honour."

" The historians of philosophy—nearly all of them German pedants—have laboured long and earnestly to depict the kaleidoscopic succession of philosophies as steps in a logical development in which every later philosopher ' pre-supposed ', and studied, all his predecessors. But the real facts were ever so much more romantic than these romances. Actually every philosophy was the offspring, the legitimate offspring, of an idiosyncrasy. The reason why so many philosophies remain mysteries is precisely because we cannot reconstruct the psychology of their authors."

" The historian of philosophy can find no consistency in any philosophy. Taken as timeless systems, all are defective, nay, incomprehensible. There is not one that is wholly consistent, no not one. There is not one which is wholly clear and intelligible, which cannot become debatable or be involved in a fog. But it never seems to occur to the critic that his *method* may be at fault. The real connexions of the philosophic system he criticizes may be psychological and æsthetic rather than logical; a system of Philosophy is best regarded as a sort of poetry, and often of lyrical poetry at that! Nevertheless he insists on viewing the system from the

outside, as a logical structure, and not as a psychological process extending over a lifetime.

"Any unity which Philosophy can aim at will have to be of a very tolerant and elastic kind, and such that it can find room for personal differences, without crumbling. This should, of course, discredit all philosophic methods which are dogmatic, authoritarian, and intolerant, and favour those which are freer and more flexible, and afford ample scope for individual differences and personal preferences."

"The great types of philosophic diversity, the great problems on which philosophers disagree, are very persistent, and exemplify themselves from generation to generation in different philosophies. They carry on an inconclusive and unending warfare, precisely because neither side has hitherto penetrated to the psychological core of its opponents' creed. Could they do so, they might understand why their traditional methods of controversy had been so ineffective."

"When two philosophers engage in controversy they hardly ever understand each other. They hardly ever even try to understand each other. They have brooded and ruminated so long over their own solitary thoughts and their own peculiar interpretations of books, that they have become almost incapable of making contact with another living mind. They shrink from such contact. So neither of them ever plays with all his cards upon the table, or even in his hand. They usually keep their best trumps up their sleeves! It is probably for this reason that both are pretty sure to have invented a technical language of their own, which departs widely from previous usage, to which they have compiled no glossary, and which they do not use consistently and without frequent relapses into more ordinary dialects. Hence they do not understand each other's language, and fight phantoms."

"The obscurity of many philosophers is notorious and indisputable; they write obscurely in order to be respected by academic colleagues who dare not criticize what they are not

sure they have understood, and in order not to be found out." *

We cannot get away from the fact that many philosophers *are* obscure, be the reason what it may. Philosophy is undoubtedly a difficult subject, but that its great issues are essentially obscure must be denied. There is a soupçon of dishonesty in the hair-splitting distinctions and in the speculative twists so common to the writings of many philosophers. Scottish philosophers and French philosophers are lucid enough. German philosophers seem almost temperamentally unable to express themselves lucidly, and the most obscure of the English philosophers * seem to be those who worship at the German philosophic shrine. As Professor Joad says, obscurity of expression on the part of a philosopher is simply bad craftsmanship. A particular philosopher's thoughts may be profound and his reasoning may be difficult to follow, but, unless he expresses his thoughts in clear language, one is always suspicious that his thoughts are never clear even to himself.

4. The A B C of Metaphysics

In order to be conscious at all, a person must be conscious of something. Consciousness therefore presents itself as the distinguishable parts of a duality, the person who is conscious and the thing he is conscious of. Philosophy indicates this contrast in various ways; it speaks of mind and matter, person and thing, soul and body, subject and object, self and non-self, the ego and non-ego. That an external world exists independently of our knowing it, is a belief that seems at once instinctive, inevitable, and necessary. We can say with certainty that when we concentrate our attention on the simplest act of perception, we have the irresistible conviction that we exist and that something else exists.

* For instance, the Late Lord Haldane: see his *Reign of Relativity*; and yet when Lord Chancellor his legal judgments were (it is said) enviable models of lucidity A former colleague of mine, J. W Headlam (afterwards Sir James Headlam-Morley) told me that when he was a post-graduate student in Germany, German students quite commonly read French translations of Kant and Hegel, which they could understand better than the German originals.

How my ego is constituted apart from my material body I do not know. I am not justified in assuming from the evidence of introspection alone that my ego is, for instance, a self-existent entity indestructible by the forces that will ultimately destroy my material body. And I am just as ignorant of the real nature of matter, for all my information about matter is derived from the senses and I know my senses may deceive me.

The cardinal fact remains, however, that mind and matter *seem* to present themselves in co-equality, though about this co-equality there is fundamental disagreement amongst philosophers.

This is partly accounted for by their disagreement about the nature of perception. The older psychology described perception as a mere conjunction of sensations or sense-data, which were received and stored as if written and recorded on a sheet of white paper; the activity of the receiving mind was practically ignored. But all perceiving involves *thinking*; new impressions received are interpreted by the mind in terms of past experience. All perception is also *conception*; the more developed the mind and the more familiar the type of object perceived, the richer is its conceptual activity in thinking. Each person's experience of things is individual; e.g. a botanist's sense-data of a rose will differ from an artist's and when their active and critical minds pass judgments on these data, their perceptions and conceptions will also be different—fundamentally different. Many things that interest the one and form part of his sense-data will be ignored by the other. Apparently they have seen the same thing, really they have seen different things. It is not surprising that about all this there is disagreement so strong as to be almost violent, and it is to this disagreement that the differences between "schools" of philosophy are largely traceable.

Philosophers of all schools, arguing from such facts as they obtain from sense-perception and from introspection—from their senses and from thinking—divide themselves into two main camps, *Dualists* and *Monists*. The Dualist accepts,

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without reservation of any kind, the fundamental fact that mind and matter are *two* separate and distinct things. The Monist denies that there are two things; he maintains that mind and matter are *one*.

But the Dualists themselves are divided into two camps, natural Dualists and metaphysical Dualists, sometimes flippantly called hard and soft Dualists, sometimes irreverently referred to as Whole-Hoggers and Doubting Thomases. The *natural Dualist* says I *know*, the metaphysical Dualist says *I am doubtful*. The natural Dualist contends that both mind and matter are real things both well known to him. The thinking part of him constitutes his *mind*; the bodily part of him, or the stone he kicks against, constitutes matter: he knows them both.

The metaphysical Dualist is more cautious. He maintains that the only positive knowledge he has of mind and matter is merely a knowledge of *phenomena*, that is, of appearances, and that these phenomena must therefore be referred to *unknown entities*, an unknown mind, spirit, soul, which perceives the facts of consciousness, and an unknown substratum or substance in which the qualities of matter inhere.

The natural Dualist readily admits the existence of separate entities, matter and mind, and says that he *knows* them. Matter is visible and tangible; the mind is his thinking self: he asks how can we possibly deny the existence of either? The metaphysical Dualist believes that entities exist but maintains that they are imperceivable and absolutely unknown; he believes they exist because necessity of thought compels him to *infer* that they exist.

Monists also range themselves into two main camps, Idealists and Materialists (mechanists). The ironical critic says of them:

"What is mind?"—"No matter."

"What is matter?"—"Never mind."

The *Idealist* maintains that *mind* was the one original thing and is still the only fundamental thing, and that matter has no real existence and is only inferred. The *Materialist*

maintains that *matter* was the one original thing and is still the only fundamental thing, and that mind is a mere halo of reflexes.

A third type of Monist is the *Objective Idealist* who maintains the co-equality of mental and material phenomena and denies the antithesis of mind and matter as separate entities; mind and matter are only modifications of a single reality.

The philosophers of all five schools are " Realists ", for they admit the existence of a reality of some kind. But the metaphysical Dualist's reality is only hypothetical.

(The letter *l* in the term Idealism is misleading; it was inserted to prevent the clashing of the vowels in idea-ism. Idealism concerns *ideas*, not ideals. It is not to be assumed that the ideals of an Idea(l)ist are nobler than those of a materialist.)

The dividing lines between one philosophic school and another are by no means so clear-cut as the preceding classification would seem to indicate. One school tends to shade off into another, and sometimes they are scarcely distinguishable. Indeed, the terminology of philosophy is most confusing, owing to the varying connotation. Even in the same " school " it is rare to find two philosophers in complete agreement.

5. The Different Philosophic Schools: some Disputed Points

There are difficulties in the way of accepting, without considerable reservation, any one of the philosophic creeds just mentioned, and to some of those difficulties we now turn.

In science, the term " phenomenon " refers to the positive facts of perception, but scientific thought goes beyond sense perception; it assumes, for instance, the existence of atoms which cannot be perceived at all. The atoms are *inferred*; and they are conceived as if they might be perceived, and with our mind's eye (if we may use the metaphor) the atoms

are seen as if under an indefinitely powerful microscope. We can verify perceptually only up to a certain point; the weakness of our senses leaves a great deal unperceived and imperceptible. It has to be admitted, unfortunately, that, while the human understanding attempts to construct conceptual systems because it is not satisfied with the contents of sense-perception alone, it sometimes uses these conceptual systems of its own construction for the purpose of disparaging sense-perception as an illusion, although aware, of course, that the suppositions of the conceptual system derive, from the data of perception, the whole of their vitality Sometimes attempts are made to construct conceptual systems which are not clearly imaginable: that way lies inevitable danger.

The metaphysical Dualist's "substance" is not phenomenal, for it cannot be made to appear to the senses. The substance is *inferred*, but it is not conceived as if it might be perceived; it is wholly unimaginable and cannot be made part of any conceptual system. The metaphysical Dualist contends that he is compelled to assume its existence, and though he admits that it is never actually seen or in any other way experienced, he maintains that it is common to all material things and is "thought into" them (whatever that may mean). "It is an undiscovered transcendent basic reality" (whatever *that* may mean). The metaphysical Dualist is just as vague about the second unknown entity, *mind* (spirit, soul). He admits that it is only inferred, that it cannot be perceived, and cannot be made part of any conceptual system, but he maintains that the inference is compulsory.

We have spoken of "phenomena" as "appearances", but the appearances are not necessarily *deceptive* appearances. There is, for instance, no other way in which the phenomenon *blue colour* can appear. But the whole question of "seeing" is full of difficulty, and we must go back to science for a few moments.

All the phenomena of the external world which we know,

of the things " out there ", are logically reducible to a comparatively small number of common " qualities ". Some of these qualities are pre-eminently real, so real that they are called *primary*: a thing is solid, resistant, heavy, long, broad, thick, in motion; and all these qualities can be *measured*; to science they are the most fundamental; and we know them from our muscular sense of resistance. But things have other qualities, viz. those associated with our other senses: things reflect light and are visible; they are resonant; they are odorous; they are sapid. These are commonly called *secondary* qualities. Between the two sets of qualities there seems to be a far-reaching distinction.

The world of primary qualities is a *permanent* world, permanent in space, permanent in time; the things " out there " retain their dimensions, their solidity, their resistant power, their weight, their motion, whether we are present or absent; we cannot bring ourselves to believe that when all percipient beings pass away the things " out there " will pass away too.

But, and it is a very big but, the world of secondary qualities *does not exist in the absence of percipient beings*. They are not permanent in time, and have no independent existence; they are not measurable except by reference to primary standards. It should not be forgotten, however, that the primary qualities, no less than the secondary, are grounded in sensations (sense-data) and are therefore liable to misinterpretation.

It must suffice to refer briefly to the secondary qualities associated with the eye.

The eye, optically a very inferior thing, is something like a camera; it is hollow, it has a lens for receiving light-rays from things outside, it has a sort of " photographic plate " on which pictures of the things outside are imprinted. The photographic plate is really the *retina*, a very fine membrane with a remarkable surface of a brush-like character. The bristle-equivalents are known as rods, so small and so closely packed together that in any human eye there are many

hundreds of millions in all. Within each and every one of them is a microscopic nerve fibril. All these fibrils, separately ensheathed, are gathered together into a single bundle, the "optic nerve", which passes out of the back of the eyeball and enters the brain, the headquarters of the nervous system.

Light-rays from the thing we are "looking at" impinge on the rod-ends, and an integrated picture of that thing is thereby imprinted on the retina. The nerve-fibril in each rod conveys to the brain the impression it has received from the particular element of the surface of the thing looked at, and the whole bundle of fibrils thus conveys to the brain all the separate impressions forming the picture on the retina. It is in the *brain* that these impressions become conscious sensations, in the *brain* where they are perceived, in the *brain* where conceptions are formed. How the brain analyses and synthesises we do not know; what part the "mind" plays (if there is a mind) we do not know. The eye does not see as the naive uninstructed plain man usually believes; the eye is just a light-gatherer and a picture-maker, and in some unknown fashion it sends on its pictures to the brain to be interpreted. That we know: that, science has established. But that is about *all* we know.

We are apt to forget all this when we lie in bed in a dark room and think of the stars outside: we think of them as if we could see them as when we are looking at them, but outside, absolutely black night reigns. Waves are streaming from the stars in the usual way, of course, but in the absence of a retina and of a brain, no sensation of "light" or "colour" can be produced. Light and colour depend for their production upon an *eye*; if the eye is not functioning there can be no light or colour for that particular person. We sit in a garden when the sun is shining, and enjoy the sight of the beautiful flowers in front of us. We are quite familiar with the garden behind us, but if we then think of it we are apt to forget that it is unilluminated, uncoloured, *black*. Again: the large object glass of a telescope acts as a light-gatherer and brings

about the formation, within the tube, of a bright image of distant objects. This image is magnified by the eyepiece and it is this magnified image (*not* the distant thing itself) that we look at. If we leave the telescope in position, and come away from it, we are apt to think that the bright image still has an objective existence in the body of the tube. Needless to say we are wrong. Once more: think of a region somewhere on the equator at midday when all living beings (we will suppose) are asleep, seeing nothing, hearing nothing, smelling nothing. We *ought* to think of it as absolutely dark, black, silent, and odourless, no matter how thunder may be rolling, lightning flashing, or aromatic plants functioning. In the absence of living things, there are no sights, sounds, or odours.

It is only by experience that we associate the retinal image with the thing itself "out there". Even a young child learns to do this: the sense of actual touch gives it assurance at a very early age. The gauging of distances takes time.

We may now go back to the philosophers.

The metaphysical Dualist accepts the "phenomena" given to him by the thing "out there"; he readily recognizes both the primary and the secondary qualities, though if he is unversed in the principles of physical science he is apt to confuse them sadly. Yet while he urges that the qualities are all we know, he maintains that we must postulate *something* in which the qualities "inhere" and he postulates his unperceivable "substance". The one thing we can get him readily to admit is that his substance is permanent in time. What he means by qualities "inhering" in the substance he cannot tell us. Sometimes he calls the substance "transcendent", another utterly meaningless term. If he would accept substance as a category, as one of those unverifiable, unanalysable, fundamental ultimate concepts which the mind is driven by necessity of thought to form, and let it go at that, instead of making a mystery of it and trying to conceal it in meaningless jargon; if he would accept it as a category indicating the reality which is not immediately given us in

perception yet felt to be necessary for the understanding of phenomena, and accept it as the result of reflection upon experience; the term would then seem to suggest something not very far removed from the ordinary matter of natural Dualism, and would be acceptable. It is his wholly unnecessary mystification that so strongly repels us.

The distinction between the two Dualists may be compared and contrasted thus: both are Realists, but in the case of the natural Dualist the real is *apprehended immediately*; he kicks against a stone and perceives it immediately and objectively—it is something solid and extended before him and it can be measured and weighed; that object he takes to be matter. In the case of the metaphysical Dualist, the real is only *inferred*. His " matter " is just a heap of sensations integrated by being thrust into and so made to " inhere " in a bodiless phantom dressed up to look like its real self. The metaphysical Dualist's substance was born in apriorism, nurtured on mysticism, and is now dying of neglect.

It may be freely admitted that our positive knowledge, the knowledge that admits of no question, of external reality, is limited to our perception of qualities. Whatever we know beyond these qualities is known by inference only, and inferences of this kind seldom admit of complete verification. But to postulate a " substance " which is utterly inconceivable is wholly irrational. When the chemist postulates atoms, or the physicist light-waves, he is at least postulating a system which is conceivable.

The main centre of interest in present-day philosophy is not, however, in Dualism but in the antithesis between the two Monistic systems, Idealism and Mechanism.

All Idealists deny the existence of matter, though some of them say that all they really deny is the unknown substratum " substance ". Some Idealists recognize the existence of soul as an entity which thinks, wills, and feels. Others limit their recognition to the much vaguer thing, mind, still conceived, however, as an entity of some sort. Still others assert that, since all we positively know of mind are the facts

of consciousness, we are not justified in assuming the existence of mind as any sort of separate entity; and they maintain that the only real things in existence are mental facts, ideas. They make vague statements about a universal consciousness, all men's minds being alike, and each mind being a sort of temporarily separated portion of this universal consciousness.

Now if we are sure of anything, it is that consciousness is personal and individual; men's minds may in many respects be alike, but their differences are great and fundamental. A common consciousness is not only unimaginable, it is inconceivable. But more than this: Idealism altogether fails to explain the primary qualities of matter—extension, inertia, impenetrability. Despite his clever paradoxes, the Idealist cannot get rid of matter by dissolving it in mind. When material objects are in question, common sense refuses to admit that *esse* and *percipi* are identical. It is impossible to accept the ultimate logical conclusion of Idealism, that, with the expiring breath of the last sentient being, the whole universe disappears into nothingness.

Mechanism is a term gradually superseding the much older term *Materialism*. This was pointed out in the last chapter. The latter term has long been used by the less tolerant theologian as a stone to throw at his opponents, Agnostics and Atheists, but its ambiguity is now generally recognized. The alternative term Mechanism implies that the human body is just an automatic machine and nothing more.

To Mechanism the only real world is the world of matter, the world of atoms with their primary qualities and motions. Life and consciousness are the products of matter, and manifest themselves in complexities of atoms. From such complexities life is, in favourable circumstances, spontaneously generated, and spontaneously generated living matter has by blind chance passed through the various stages of evolution until the human being has reached his present state of development. There is no God, no soul, no freedom. The mind is nothing more than a function of the brain. All

psychical facts are merely effects, though unexplained effects, of cell-movements in the brain. The whole secret will some day be found in reflexes—in the purely mechanical shuttle-like action of nervous impulses.

The claims of mechanism lead to far-reaching logical consequences. For the mechanist asserts that all our volitions are mere links in a mechanical chain of blind causes and effects. But it is a chain without a staple. As Coleridge would say,* "it is like a chain of blind men, each holding the skirt of the man before him, reaching far out of sight but all moving without the least deviation in one straight line. It would naturally be taken for granted that there was a guide at the end of the file. But no; for are not the men without number? and does not infinite blindness supply the place of sight?"

Assuredly men act in consequence of motives, and their motives are the results of preceding acts, so that if we knew the antecedents of these acts and the laws that connect them, we could with infallible certainty predict the consequences, immediate and remote. To the mechanist, the human will counts for nothing, and can effect nothing; our every decision is the infallible consequence of particular cerebral changes. The individual who, while balancing two courses, is under the impression that he is at liberty to pursue either, is completely under a delusion. The most calculating selfishness, the most heroic self-sacrifice, equally have been determined by chance aggregations of atoms. Newton and Shakespeare were not creative personalities. They were merely automata with fortuitously specially active reflexes. It is pure imagination, says the mechanist, that we ever act from rational motives. No criminal is morally reprehensible; he is simply morally irresponsible. How can a mechanist give his support to any sort of penal code? Hang a man for murder? Shocking! That would be as irrational as rewarding a man for valour, or for success in some great undertaking. Reward and punish bundles of reflexes! And yet the mechanist, emotionless automaton though he be, can enjoy a good dinner! Of course he

* See his *Biographia Literaria*.

would deny that there was any enjoyment in the popular sense. Any trace of fastidiousness in his epicureanism he would explain as just the special automatic behaviour of his palatal reflexes.

It cannot be said that either Idealism or Mechanism is a fundamentally illogical system. Each is logically worked out, but neither is acceptable because of the ultimate consequences traceable from its hypotheses; in fact, every system seems to break down that refuses to accept the cardinal facts of the duality of consciousness. Mind and matter are two entirely distinct things present to our consciousness; they cannot be reduced the one to the other, in the first place because matter is inexplicable by the qualities of mind or spirit, and in the second because consciousness is inexplicable by the qualities of matter; the refusal to accept the great underlying fact of duality of consciousness is an act of philosophic suicide.

There is not a philosophic system but is open to attack, for every system rests on hypotheses which, ultimately, are not verifiable. Both kinds of dualism are attacked: Natural Dualism because it takes too much for granted, Hypothetical Dualism because of the assumption of inconceivable entities. Still, the ultimate consequences of Dualism are not so destructive as are the consequences of Monism.

There are some philosophers who shrink from the laborious study of the detailed knowledge derived from the senses, and prefer to pin their faith on the wisdom, sudden and penetrating, which they believe will reach them by thinking and reasoning. In their more emotional moods, a "belief" in the unreality of the world of Science assails them with irresistible force, and when this emotional intensity subsides they seek for logical reasons in support of that belief.

The attitude is altogether wrong. There must be no shrinking from hard facts, no demand in advance that the world shall conform to preconceived desires. Knowledge of the universe is not hidden by a flimsy veil that can be easily torn aside; it is very hard to come by.

6. From the Older Philosophers to the Newer

The greatest philosopher the world has ever known was the Greek Plato (427–347 B.C.) though in some ways his pupil Aristotle (384–322 B.C.) was perhaps even greater: certainly he was more systematic. The philosophers of the first few centuries of the Christian era were not outstanding; they were certainly the intellectual inferiors of Plato and Aristotle. Several of them took a hand in helping to formulate the Christian creeds, and the help they gave does not redound very much to their credit; they neglected, in far too great a degree, the work of the great pre-Christian philosophers, Plato and Aristotle. The philosophers of mediæval times were, on the whole, men of much greater intellectual calibre, but they wasted much of their time in wordy hair-splitting in support of the Church. They were mostly apriorists and logicians, belittling or ignoring any facts which did not fit into their schemes. With the Renaissance it began to be realized how much pre-Christian civilization had meant, how sound had been much of the ancient Greek philosophy, and how many of the existing theological ideas were being overthrown by the new scientific discoveries of Galileo and his successors. The first modern philosopher of eminence was the Frenchman, **Descartes** (1596–1650). Then came three British philosophers, **Locke** (1632–1704), **Berkeley** (1685–1753) and **Hume** (1711–76), representatives, in their different ways, of Subjective Idealism. They were followed by the two German philosophers, **Kant** (1724–1804), and **Hegel** (1770–1831), the two great figures of Objective Idealism. The outstanding feature of the philosophy of Kant and Hegel is its obscurity, and many a man has obtained his coveted First in Greats at Oxford because of his ingenious and more or less intelligible expositions of what was believed to be what Kant and Hegel meant. If the reader desires a little entertainment, let him ask half a dozen philosopher friends to write out an explanation of Hegel's *Absolute*, say

in a thousand words. The accounts will probably differ so much as almost to be unrecognizable as describing the same thing. That hard-headed and exceedingly able Scottish philosopher, Sir William Hamilton, regarded the Absolute as one of the most fantastic conceptions ever put forward. It was an all-embracing concrete thing, sometimes an all-embracing abstraction, sometimes God, sometimes an eternal calm, sometimes a principle of order, sometimes a totality of all existence and of thought. And so on, almost indefinitely.

However, the Absolute has at last disappeared. Idealism has been refuted, though, as we shall see, certain mathematicians claim to have discovered a sort of ghost of its former self. The leading school of present philosophic thought is represented by Professor **C. D. Broad** and Professor **C. E. M. Joad**, both Englishmen; Professor **John Laird**, a Scotsman, and Professors **Holt, Montague,** and **Perry**, Americans. All are Realists of some kind, and perhaps the term Common Sense Realists would apply to them. Professor Joad seems to be a Natural Dualist, but any label applied to any modern philosopher may do him an injustice. A general characteristic of the books of modern philosophers (except **Whitehead**) is lucidity. One may read Professor Joad's books from cover to cover without finding either obscurity or ambiguity.

The modern philosopher rarely tries to create a system which is closed and final. Rather, he is a critic, a somewhat ruthless critic, perhaps, but an eminently rational one. But if he is a critic, he is also a helper. He helps, for instance, to rescue science when science is obviously taking the wrong path. He would help theology, but even in these days the theologian may sometimes be heard to maintain that his fortress is impregnable, and that he needs no help from either philosophy or science.

Dr. Schiller, in an article which appeared in the *Albany Review* for March, 1908, *The Tribulations of Truth*,* made an amusing forecast of the then approaching change:

* Reprinted in his book *Must Philosophers Disagree?*

"Philosophy is not a subject a healthy human mind takes any natural interest in. It is too lofty, complicated, difficult, abstruse, dull, and dignified; it has too little reference to human life and action. Regarded as a science, it inspires no confidence, because it exhibits no consensus of authority, no array of undisputed truths: regarded as an intellectual game, it is not an amusing one to watch, because it looks as though all the players were continually making new rules, and no one for any length of time observed any rule whatsoever. So the student of human society and its freaks has accustomed himself to regard the philosopher as a mild kind of crank, who, however, fortunately does very little harm so long as he is kept in proper obscurity, and the world in general is content to pay no attention at all to anything a philosopher may say or think either about it or about the other philosophers.

"Nowadays, however, the peace of this indifference has been endangered. The world is dimly beginning to perceive that there is an unusual commotion going on in its philosophic corners, that the Doctors of Philosophy are disagreeing with unprecedented violence, that the sharpest contentions of the irritable race of poets exhibit a profoundly 'philosophic calm' in comparison with those of sages—in short, that something has happened. Nay, more; some philosophers are actually coming out of their obscurities and becoming lucid and almost luminous, as if they were trying to appeal to a wider public. The others are frantically trying to explain why these disreputable traitors should on no account be allowed a hearing. In short, a perfect deluge of turbid and chaotic thought threatens to descend upon a puzzled public.

"Meanwhile the poor public has hardly yet been given a chance of seeing clearly what is the source of this whole commotion, or of understanding why it should be asked to take an interest therein, and before the plot thickens further it may be well to attempt a little elementary elucidation.

"The truth is that the whole hubbub has been caused by the fact that a few philosophers have, quite unexpectedly

and to the dismay of their colleagues, discovered that human life and its problems, crude common living and the practical questions it raises, is at bottom the main problem also for the most refined 'philosophy'. In the first enthusiasm of this great (though belated) discovery, they have proceeded to evolve a 'humanist' philosophy which seems to be, in character and aims, the very opposite of all the qualities usually associated with the term 'philosophy'. It is straightforward, simple, easy, entertaining, lucid, undogmatic, and not in the least bit haughty; it is in love with human life, and eager to be practical and useful; so tolerant and democratic that it lets every man have his own truth and be the judge of his own experience, and grants him a vote in the making of that truth, to agree upon which is so necessary and difficult an achievement of civilized intercourse. The result is, of course, that the old despotic Truth that claimed a celestial descent and always pretended absolutely to control whatever subjects she graced with her august presence, is in desperate trouble, and threatened with supersession and oblivion by the meretricious allurements of a younger double, a new Truth willing to be the companion and the slave of man, and to share the vicissitudes of his mortal life. Instead of claiming infallibility and dictating sternly and tyrannically to her cowering subjects, the newcomer is anxious only to help and to please: her modest ambition is not to compel and to constrain, but merely to propound a convenient set of rules by the aid of which every one may seek his spiritual salvation and play his intellectual game for all he—and it—is worth, without interfering with the equal liberty of others.

"It will readily be understood what a scandal this appearance of Truth *en canaille* was bound to cause among sedate philosophers, how outrageously it seemed to them to run counter to all they held dear and philosophic, how hopelessly it seemed to profane their most cherished mysteries. In their zeal to vindicate their dignity, all other interests were obliterated. No one stopped to consider whether the new view of Truth did not proffer solid compensations for the

imaginary loss in rank, and whether it would not redound greatly to the advantage of philosophy and its votaries, as well as of society, if the world could be thoroughly convinced that Truth was valuable and useful, to be loved and not to be feared. After a short interval of stupefied amazement, they threw themselves upon the insolent upstarts who had dared to turn their sacred studies topsy-turvy.

"Yet, strange to say, the innovators have declined to consider themselves crushed. They continue to talk back gaily."

7. The New Idealism and its Sponsors

Sir Arthur Eddington and **Sir James Jeans** are two well-known Cambridge mathematicians who have taken great interest in Astronomy; indeed, the former holds the Plumian chair of Astronomy. And both evidently have a good working knowledge of physics. Their mathematical work commands respect and assent throughout the mathematical world, but as interpreters of mathematical results they are not always followed, and sometimes they are opposed. The reasons for this opposition seem to be: (1) their interpretations are put forward a little dogmatically, and as if these were inevitable interpretations; (2) they have adopted a philosophic attitude which it is exceedingly difficult to justify so far as its basic relations to mathematics and physics are concerned; (3) they have attempted (in books for which we certainly all feel admiration) to give popular accounts of extremely technical work in mathematics and physics. These books have admittedly excited a tremendous amount of public interest and have helped the plain man to understand much about modern physical science. But much of the technical evidence on which some of the opinions were based is, necessarily, omitted, and thus the views of readers of the books are, almost inevitably, likely to be tinged with the personal philosophic prepossessions of the authors. We

refer, in the main to Eddington's *Expanding Universe* and Jeans' *Mysterious Universe*.

Ever since the books appeared, commentators and critics have been busy in all parts of the English-speaking world. The two writers are by no means in entire agreement on all points, but they both show the same general drift towards a special kind of philosophic Idealism. They have been accused of flirting with Berkeleianism, a bold maid famous for her pretence of being coy but known to be very wilful.

Sir Arthur Eddington is much the easier to understand. He leaves us in little doubt as to what he means, even when we are unable to share his views. In his book *The Nature of the Physical World* he quotes an imaginary though typical question from an examination paper in physics. It begins thus: "An elephant slides down a grassy hillside. The mass of the elephant is two tons. The slope of the hill is 60°." Sir Arthur quite correctly points out that the candidate does not think of the elephant *as* an elephant at all; he attends to a mere mass of two tons, as indicated by the pointer of a weighing machine; he does not think of the hill *as* a hill, but merely of a plumb-line against the 60° mark on a protractor; he does not think of the softly yielding turf *as* turf, but of a mere coefficient of friction, a mere number obtained by a method kindred to a pointer reading. Thus all "poetry fades from the problem"; so does real science; the candidate is not concerned with physics but merely with pointer-readings and with the working of a sum. "The question presumably was to find the time of descent of the elephant, and the answer is again a pointer reading, on the seconds dial of our watch."

Now whether we agree with Sir Arthur or not, we do at least understand him. But we have to bear in mind that he is a mathematician and not a physicist, and that it is quite natural he should attach primary importance to mathematical relations. We may feel quite certain, for instance, that when he is working out some abstruse mathematical problem in astronomy, perhaps concerning stellar distances, "all

poetry fades out of the problem", and he is just working a sum.

Sir Arthur refers to "Reality" thus: "I am afraid of this word Reality, not connoting an ordinarily definable characteristic of the things it is applied to but used as though it were some kind of celestial halo. I very much doubt if any one of us has the faintest idea of what is meant by the reality or existence of anything but our own Egos. . . . In physics we can give a cold scientific definition of reality which is free from all sentimental mystification. But this is not quite fair-play, because the word 'reality' is generally used *with the intention of evoking sentiment.* It is a grand word for a peroration. 'The right honourable speaker went on to declare that the concord and amity for which he had unceasingly striven had now become a reality (loud cheers). The conception which it is so troublesome to apprehend is not "reality" but "reality" (loud cheers)'." *—This is good fun, but it is good logic, too.

One more quotation:

"The recognition that our knowledge of the objects treated in physics consists solely of readings of pointers and other indicators transforms our view of the status of physical knowledge in a fundamental way. Until recently it was taken for granted that we had knowledge of a much more intimate kind of the entities of the external world. Let me give an illustration which takes us to the root of the great problem of the relations of matter and spirit. Take the living human brain endowed with mind and thought. Thought is one of the indisputable facts of the world. I know that I think, with a certainty which I cannot attribute to any of my physical knowledge of the world. More hypothetically, but on fairly plausible evidence, I am convinced that you have minds which think. Here then is a world fact to be investigated. The physicist brings his tools and commences systematic exploration. All that he discovers is a collection of atoms and electrons and fields of force arranged in space

* *op. cit.*, pp. 282–3.

and time, apparently similar to those found in inorganic objects. He may trace other physical characteristics, energy, temperature, entropy. None of these is identical with thought. He might set down thought as an illusion—some perverse interpretation of the interplay of the physical entities that he has found. Or if he sees the folly of calling the most undoubted element of our experience an illusion, he will have to face the tremendous question, How can this collection of ordinary atoms be a thinking machine? But what knowledge have we of the nature of atoms which renders it at all incongruous that they should constitute a thinking object? The Victorian physicist felt that he knew just what he was talking about when he used such terms as *matter* and *atoms*. Atoms were tiny billiard balls, a crisp statement that was supposed to tell you all about their nature in a way which could never be achieved for transcendental things like consciousness, beauty, or humour. But now we realize that science has nothing to say as to the intrinsic nature of the atom. The physical atom is, like everything else in physics, a schedule of pointer readings. The schedule is, we agree, attached to some unknown background. Why not then attach it to something of spiritual nature of which a prominent characteristic is *thought*. It seems rather silly to prefer to attach it to something of a so-called 'concrete' nature inconsistent with thought, and then to wonder where the thought comes from. We have dismissed all preconception as to the background of our pointer readings, and for the most part we can discover nothing as to its nature. But in one case—namely, for the pointer readings of my own brain—I have an insight which is not limited to the evidence of the pointer readings. That insight shows that they are attached to a background of consciousness. Although I may expect that the background of other pointer readings in physics is of a nature continuous with that revealed to me in this particular case, I do not suppose that it always has the more specialized attributes of consciousness. But in regard to my one piece of insight into the background, no

problem of irreconcilability arises; I have no other knowledge of the background with which to reconcile it.

"In science we study the linkage of pointer readings with pointer readings. The terms link together in endless cycle with the same inscrutable nature running through the whole. *There is nothing to prevent the assemblage of atoms constituting a brain from being of itself a thinking object in virtue of that nature which physics leaves undetermined and undeterminable.* If we must embed our schedule of indicator readings in some kind of background, at least let us accept the only hint we have received as to the significance of the background—namely that it has a nature capable of manifesting itself as mental activity." *—Sir Arthur's reasoning is unexceptionable, but that "background": how badly it seems to need illuminating.

We may now refer to some of the opinions of Sir James Jeans. We quote from the last chapter of *The Mysterious Universe*; it is entitled *Into the Deep Waters*.

"A soap-bubble with irregularities and corrugations on its surface is perhaps the best representation of the new universe revealed to us by the theory of relativity. The universe is not the interior of the soap-bubble but its *surface*, and we must always remember that, while the surface of the soap-bubble has only two dimensions, the universe-bubble has four—three dimensions of space and one of time. And the substance out of which this bubble is blown, the soap-film, is empty space welded on to empty time. . . . The ether which was at one time supposed to fill the universe has been reduced to an abstraction, a frame-work of empty space, amounting to nothing more than the spatial dimensions of a soap-bubble, whose soap-film consists of vacancy." †—Observe that the *substance* of this remarkable bubble "consists of vacancy", and it is "empty space welded into empty time".

Again: "The markings which represent matter tend to

* *ibid.*, pp. 258–60. † *op. cit.*, pp. 114, 120.

form broad bands across the surface of the soap-bubble, like broad streaks of paint on a canvas. This is because the matter of the universe tends to aggregate into large masses—stars and other astronomical bodies. These bands or streaks are known as 'world lines'; the world line of the sun traces out the position of the sun in space. . . . Just as a cable is formed of a great number of fine threads, so the world line of a large body like the sun is formed of innumerable smaller world lines, the world lines of the separate atoms of which the sun is composed. . . . We may think of the surface of the bubble as a tapestry whose threads are the world lines of atoms. . . . The world line of the earth is a smaller cable, made up of several strands, these representing the mountains, trees, aeroplanes, human bodies, and so on, the aggregate of which makes up the earth. Each strand is made of many threads—the world lines of its atoms. A strand which represents a human body does not differ in any observable essentials from the other strands. . . . Yet the threads which represent the atoms of a human body have the special capacity of conveying impressions through our senses to our minds. These atoms affect our consciousness directly. . . . We can most simply interpret consciousness as something residing entirely outside the picture, and making contact with it only along the world lines of our bodies. . . . The ether which was at one time supposed to fill the universe has been reduced to an abstraction, a frame-work of empty space, amounting to nothing more than the spatial dimensions of a soap-bubble, whose soap-film consists of vacancy." *

What exquisite tapestry covers that bubble! It is said that there are about 10^{77} individual atoms in the universe; there are therefore 10^{77} elementary world lines or threads, these being spun into strands, and these again into cables. Why did not Sir James give a world line to each of every atom's spinning electrons? How he would have added to the richness of the pattern of his tapestry then!

And again: "The essential fact is simply that *all* the

* *op. cit.*, pp. 116, 118, 120.

pictures which science now draws of nature, and which alone seem capable of according with observational fact, are *mathematical* pictures." *—What do the biologists say to that? and the chemists? and the great majority of physicists? and the astronomers? **All** their pictures mathematical!

Once more: "Our efforts to interpret nature in terms of the concepts of pure mathematics have, so far, proved brilliantly successful. . . . The terrestrial pure mathematician does not concern himself with material substance, but with pure thought. His creations are not only created by thought but consist of thought, just as the creations of the engineer consist of engines. And the concepts which now prove to be fundamental to our understanding of nature . . . seem to my mind to be structures of pure thought, incapable of realization in any sense which would properly be described as material. . . . To my mind, the laws which nature obeys are less suggestive of those which a machine obeys in its motion than of those which a musician obeys in writing a fugue, or a poet in composing a sonnet. The motions of electrons and atoms do not resemble those of the parts of a locomotive so much as those of the dancers in a cotillion. And if the 'true essence of substances' is for ever unknowable, it does not matter whether the cotillion is danced at a ball in real life, or on a cinematograph screen, or in a story of Boccaccio. If all this is so, then the universe can be best pictured although still very imperfectly and inadequately, as consisting of pure thought, the thought of what, for want of a wider word, we must describe as a mathematical thinker."†

"If the universe is a universe of thought, then its creation must have been an act of thought. . . . Time and space, which form the setting for the thought, must have come into being as part of this act. Primitive cosmologies pictured a creator working in space and time, forging sun, moon and stars out of already existent raw material. Modern scientific theory compels us to think of the creator as working outside time and space, which are part of his creation, just as the

* *op. cit.*, p. 127. † *op. cit.*, pp 133, 135, 136.

artist is outside his canvas. . . . The universe shows evidence of a designing or controlling power that has something in common with our own individual minds—not, so far as we have discovered, emotion, morality, or æsthetic appreciation, but the tendency to think in the way which, for want of a better word, we describe as mathematical." *

Now the Creator may have done His work from some place, "outside space", "just as the artist is outside his canvas", though His pied-à-terre is not very obvious. But to conceive Him as primarily a mathematician! as one who spends His time in working sums, solving differential equations, and playing games with Riemann-Christoffel curvature tensors! Is not this just a little irreverent? May we not far more convincingly argue that He is a Master Architect, a Master Builder or a Master Engineer, or (since we know on unimpeachable authority that "the effectual fervent prayer of a righteous man availeth much" and that prayers are offered up in scores of different languages), a Master Linguist?

It has been said that when Sir James Jeans took a header into those "deep waters" of philosophy, he divested himself of his workaday garments and went in,

> "Clothed in white samite, mystic, wonderful,"

overlooking the fact that this beautiful glossy material, "warp of silk and weft of gold", was precisely that material which, when wet, lost much of its protecting opacity, a fact which several of Sir James's admiring friends were not slow to discover. Some of them became critical, as the following extracts show:

Mr. **Bertrand Russell**, another eminent Cambridge mathematician, says (*The Scientific Outlook*, pp. 115–8):

"The last chapter of the book is concerned to argue that this soap-bubble has been blown by a mathematical deity because of His interest in its mathematical properties. Sir

* *ibid.*, pp. 144, 145, 149.

James Jeans's God, like Plato's, is one who has a passion for doing sums, but being a pure mathematician, is quite indifferent as to what the sums are about. By prefacing his argument by a lot of difficult and recent physics, the eminent author manages to give it an air of profundity which it would not otherwise possess. In essence the argument is as follows: since two apples and two apples together make four apples, it follows that the Creator must have known that two and two are four. To speak seriously: Sir James Jeans reverts explicitly to the theory of Bishop Berkeley, according to which the only things that exist are thoughts, and the quasi-permanence which we observe in the external world is due to the fact that God keeps on thinking about things for quite a long time. The Universe, he says, ' can best be pictured, although still very imperfectly and inadequately, as consisting of pure thought, the thought of what, for want of a wider word, we must describe as a mathematical thinker.'

" The argument is, of course, not set out with the formal precision which Sir James would demand in a subject not involving his emotions. Apart from all detail, he has been guilty of a fundamental fallacy in confusing the realms of pure and applied mathematics. Pure mathematics at no point depends upon observation; it is concerned with symbols, and with proving that different collections of symbols have the same meaning. Physics, on the contrary, however mathematical it may become, depends throughout on observation and experiment, that is to say, ultimately upon sense perception. The physicist asserts that the mathematical symbols which he is employing can be used for the interpretation, colligation, and prediction of sense impressions. However abstract his work may become, it never loses its relation to experience. It is found that mathematical formulæ can express certain laws governing the world that we observe. Jeans argues that the world must have been created by a mathematician for the pleasure of seeing these laws in operation. If God were as pure a pure mathematician as His knightly champion supposes, He would have no wish to

give a gross external existence to His thoughts. The desire to trace curves and make geometrical models belongs to the schoolboy stage, and would be considered *infra dig.* by a professor. Nevertheless it is this desire that Sir James Jeans imputes to his Maker. The world, he tells us, consists of thoughts; of these, there are, it would seem, three grades: the thoughts of God, the thoughts of men when they are awake, and the thoughts of men when they are asleep and have bad dreams. One does not quite see what the two latter kinds of thought add to the perfection of the universe, since clearly God's thoughts are the best, and one does not quite see what can have been gained by creating so much muddle-headedness. I once knew an extremely learned and orthodox theologian who told me that as the result of long study he had come to understand everything except why God created the world. I commend this puzzle to the attention of Sir James Jeans, and I hope he will comfort the theologians by dealing with it at no distant date."

Professor **Herbert Dingle** thinks that Eddington and Jeans have reached invalid inclusions; he denies the primacy that they assign to mathematics. In his *Science and Human Experience* he says:

"According to Eddington nothing that is not metrical in character can be treated scientifically. Jeans goes still further in the same direction. To him, not only Science, but the whole external universe, is metrical. 'The final truth about a phenomenon,' he writes, 'resides in the mathematical description of it; so long as there is no imperfection in this our knowledge of the phenomenon is complete.' This conclusion seems to me to be contrary not only to reason but to actual fact."

"It is of course obvious that a large part of the data of Science is non-metrical in character. The schoolboy's name for chemistry is 'stinks', not 'balances', and a very appropriate name it is. Biologists observe the flight of birds very closely, but they do not trouble to apply the Fitzgerald-

Lorentz contraction, not because it is too small to be important, but because it has no relation to the *kind* of observation they are interested in. It is clear, therefore, that much of the recording and augmentation of our experiences, which is essentially scientific, is not metrical. This is in itself sufficient to refute the doctrine in question.

"Even in the metrical part of our experiences there are phenomena which lie outside it. Take motion, for example. The system includes the motion of a comet, but it does not include the motion of a fly. We need consider none of the non-metrical aspects of the fly, but only its motion as a piece of matter. The matter is made up of protons and electrons, formed into atoms indistinguishable from those of the comet, and its motion can be described completely in terms of space and time. Nevertheless, the motion of the fly is essentially of a different character from that of the comet; it cannot be included within the closed system of metrical physics. Although itself metrical, we can make nothing intelligible out of it unless we associate it with something non-metrical, which we call 'life'."

Concerning Eddington's illustration of the elephant sliding down a grassy slope, Professor Dingle says (*op. cit.*):

"Suppose the further question is put: 'To find the damage done to the elephant.' 'Two tons' is of no use now; the living, struggling, trumpeting animal must be reckoned with. We can do without the knowledge of the slope of the hill, and the coefficient of friction 'leaves us cold'. As before, the poetry fades out of the problem, and this time it takes the metrical elements with it; but there is still something left, and that something is scientific in character. It involves such things as abrasions and broken limbs; it is approachable with chloroform and X-rays; the problem requires a knowledge of the anatomical structure and physiological processes of elephants—that is, scientific knowledge; and the answer can be stated in scientific terms conveying the same meaning to all normal people.

"The division of common experience into metrical and

non-metrical parts, of which only the former can be dealt with scientifically, therefore appears too simple. The *whole* of common experience is open to scientific treatment." *

Professor **J. B. S. Haldane,** Biologist, Biochemist, Geneticist, and Mathematician, says in *The Inequality of Man*:

"In England the most widely read writers on science are Russell, Eddington, and Jeans. It is not a mere coincidence that all three are first-rate mathematicians, that is to say experts in the use of symbols Russell and Jeans, so far as I know, have never published the result of a single observation of nature, much less of an experiment. Eddington is a great observer, but not a great experimenter. Hence although these three differ on fundamental problems, from the existence of God downwards, their scientific experience is almost wholly confined to the art of organizing *known* facts, rather than eliciting *new* facts from nature. Hence their account of the scientific outlook is inevitably different from that of the laboratory worker." Referring to a statement by Russell that "science as the pursuit of truth is being killed by a scepticism which the skill of the men of science has generated", Professor Haldane says: "As a director of research in two laboratories I find no sign of this scepticism among the workers there, nor do I find it among my colleagues who are researching in experimental physics. They mostly hold that if Eddington or Russell really believes that the universe is expanding, or has no coherence or order, this merely shows that symbols can be as intoxicating to mathematicians as are ordinary words to politicians."—Clearly Professor Haldane's Deity is *not* a mathematician.

In *The Frontiers of Psychology*, Professor **William McDougall,** who is recognized as the leading psychologist

* For a trenchant article by Professor Dingle on *Modern Aristotelianism*, see *Nature*, May 8, 1937 This was followed up, June 12, 1937, by reasoned replies from Professor Milne, Professor Eddington, Professor Dirac, Professor Haldane, Professor Darwin, and others, with a final reply by Professor Dingle All the articles are eminently well worth reading

in America and is greatly respected by his colleagues in Britain (he was formerly Reader at Oxford) regrets that men of science so often rely upon the crude misleading psychology embedded in common language and literature, and to substantiate this statement he quotes the following from Sir James Jeans (*The Mysterious Universe*):

"Objective realities exist, because certain things affect your consciousness and mine in the same way, but we are assuming something we have no right to assume if we label them as either 'real' or 'ideal'. The true label is, I think, 'mathematical'. . . . The label we have selected does not of course relegate matter into the category of hallucinations or dreams. The material universe remains as substantial as ever it was, and this statement must, I think, remain true through all changes of scientific or philosophical thought."

And then Professor McDougall points out that on another page Sir James foresees the universe as "totally devoid of substance", and he quotes further:

"*For substantiality is a purely mental concept measuring the direct effect of objects on our sense of touch*. . . . Yet the fact that we possess no absolute extraneous standard against which to measure substantiality does not preclude our saying that two things have the same degree, or different degrees, of substantiality. . . . Creations of an individual mind may reasonably be called less substantial than creations of a universal mind. A similar distinction must be made between the space we see in a dream and the space of everyday life: the latter, which is the same for us all, is the space of the universal mind. It is the same with time, the time of waking life, which flows at the same rate for us all, being the time of the universal mind."

Then Professor McDougall comments thus:

"With this and much more of such 'fine confused feeding' does our most popular exponent of physical truth lead up to his much celebrated pronouncement about the Great Mathematician. What I am concerned to point out is the fact that the *pièces de résistance* of this farrago, the meaty

chunks of this haggis, are scraps of popular psychology, all false or very disputable or so vague as to be highly ambiguous. Wrestle with the sentence I have italicised and what can you make of it?" *

We have now cited opinions of recognized authorities in mathematics, physical science, biological science, and psychology. We may close the chapter by quoting from one of the works of the best-known of our younger philosophers, Professor C. E. M. Joad: *Philosophical Aspects of Modern Science*: †

" I am making two points, one of which relates to observation, the other to reasoning.

" (1) The world which the scientist observes is the familiar world known in sense experience. If this is not objectively real, then his observations which purport to reveal to him a world other than himself are misleading. Conclusions about the universe based upon these observations are, therefore, untrustworthy. The philosophies of Professor Eddington and Sir James Jeans consist of conclusions so based.

" (2) The scientific world is reached by inference and deduction from experiments performed on objects belonging to the familiar world. The conclusion that the material world contains such entities as atoms and quanta is, therefore, one which is reached by reasoning. The metaphysical views of Sir James Jeans and Professor Eddington are reached by a further process of reasoning, which takes as one of its starting-points the existence of such entities as atoms and quanta considered as real facts. This further process of reasoning leads to the metaphysical conclusion that the universe is not such as to contain atoms and quanta as real and independent facts; they are abstractions and symbols; what is real is mind. Hence, if the further process of reasoning is valid, the first process of reasoning was mistaken. But the further process of reasoning takes as one of its starting-points con-

* *op. cit.*, pp. 84–5. † *op. cit*, pp. 120–2.

clusions reached by the first. Hence, if the further process concludes that the results of the first process are mistaken, the further process is vitiated by the mistaken results upon which it is based. But, if the further process is vitiated, there is no reason to accept its conclusions to the effect that the first process is mistaken. Hence the world may in fact contain such entities as quanta and atoms as objectively real constituents.

"If these considerations are valid, their moral seems to be, first, that metaphysical reasoning which is based on the conclusions of science cannot legitimately be used to discredit observation of the familiar world, or to suggest that such observation does not truly acquaint us with the nature of what objectively is. If it is so used, it undermines its own foundations. Secondly, metaphysical reasoning based on scientific results cannot be legitimately employed to show that scientific reasoning which appears to be valid, in the sense that it is conducted according to the accepted laws of reasoning, is in fact invalid in the sense that it reaches misleading results. If it is so used, the suspicion that it casts upon the human reasoning faculty inevitably reflects upon itself. In other words, the metaphysical reasoning of modern scientists, in suggesting, as it does, that their reasoning as scientists did not reach true conclusions about the world, suggests also that it does not itself reach true conclusions about their reasoning as scientists.

"The following results emerge. The philosophies of the universe put forward by Professor Eddington and Sir James Jeans which I have considered are based upon the interpretation of modern physics. As such they are open to objection in the following respects:

"(1) Because they regard the familiar world of sense experience as not objectively real, but in some sense a product of the observer's mind.

"(2) Because they regard the world of modern physics as not objectively real, but in some sense a product of the scientist's reasoning.

"(3) Because they despise brute collocations of given fact and seek to analyse them away into mind or law.

"(4) Because, starting from certain premises, namely, what the plain man perceives and what science has discovered, they reach conclusions which suggest that the premises are misleading in the sense that the plain man does not perceive what he thinks that he perceives, and the discoveries which science has made do not truly represent the nature of what is.

"Now these mistakes, if mistakes they are, arise, I suggest, not from false science, but from false theory of knowledge. What, I cannot help feeling, eminent scientists misconceive is the nature of the act of knowing and the nature of its relation to the object known."

Professor Joad's reasoning should be closely followed. It is cogent and his conclusions seem to be irrefragable. But "eminent scientists" in his last sentence should read "eminent mathematicians".

Professor Joad recognizes that human thought is still in its very early infancy. Metaphysicians probably have millions of years ahead of them to think otherwise, to demolish old systems and to reconstruct new ones. He says: (*Guide to Philosophy* (pp. 156–8):

"It seems to be exceedingly unlikely that the truth about the universe as a whole has yet been discovered by any human mind. How unlikely, may be inferred from a brief reference to certain time facts. The whole past of *life* from its earliest beginnings upon the earth is broadly reckoned at about 1,200,000,000 years.* The past of human life, is estimated roughly at about 1,000,000; of human civilization, on the most generous interpretation of the word "civilization" at about 3000. If only a small part of the truth about the universe has been revealed to the human mind in the three thousand years of its thinking history, one cannot help wondering how our descendants will occupy their no doubt infinitely more

* "The estimate is exceedingly rough; it may be incorrect by hundreds of millions of years."

powerful intelligence during the twelve hundred thousand million years of man's future. From the point of view of these descendants, we can only hope that it is unlikely that the metaphysicians of the past and present have discovered any large measure of truth about reality. This hope is almost certainly justified; and, even if most systems of metaphysics are not, in the words of a contemporary philosopher, adequately described as 'variations on the theme of cosmic lying', it would be unwise to accept any metaphysical account of the universe as embodying absolute truth. This pessimistic view as to the achievement and prospects of metaphysics should not discourage prospective metaphysicians. No man with a tincture of philosophy will, indeed, be induced to abandon his efforts to probe the nature of reality by the reflection that he is unlikely to be successful. In any event, since reality as conceived by most philosophers is that which, being independent of *human* thought, is the same for all thinkers, reality really *is* there, waiting to be discovered in a sense in which the world of appearance, being to some extent dependent upon and relative to the observer, is not. This distinction is frequently described by the assertion that reality is objective whereas appearance is subjective."

Philosophy, like science is still a very young child. It has not yet learnt to interpret its perceptions aright and it often gauges its distances incorrectly; it stretches out its little hand and burns its fingers, and it mistakes a pretty reflecting surface for deep waters. But it is beginning to express itself in simple language quite intelligibly, and there is every hope of a healthy and intelligent development. Some earlier signs of an incomprehensible precocity are passing away.

Philosophy does not yet know. Nevertheless it is an invaluable collaborator. For it knows that *we* don't know, and it convinces us all, scientists, mathematicians, theologians, or what not, that we are profoundly ignorant. It leaves no weak joint undiscovered too in our intellectual armour. It is always ready to take the ring, and almost always victorious.

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CHAPTER XI *

Religious Persecution

1. The Doctrine of Exclusive Salvation

The Mosaic Law, with its stern negative moral prohibitions, refers to the Jewish God as a "jealous" God, and even as a vindictive God, for He visits the sins of the fathers upon the children even to the third and fourth generation. In contrast to this, the Founder of Christianity summed up human duties in the two positive precepts of love to God and love to man.† It is a painful fact that the Christian church has built up a system of theology which gives far greater prominence to the Old Testament prohibitions than to Christ's positive precepts. A man may love God, may love his neighbour, and may be the embodiment of every Christian virtue, but unless he believes exactly as the Church orders him to believe, he will be condemned to everlasting punishment.‡ The Church may embody in its creed a dogma which was adopted by a bare majority of an ancient council after prolonged and embittered controversy, a dogma supported by evidence which no modern court of justice would for a moment consider valid; no matter: believe it, or be everlastingly damned.

The Christian Church has won its greatest victories by inspiring *fear*, and it has been guilty of the most atrocious persecutions. Even in its early days it taught that all the piety and all the virtues of every man outside its own small

* See footnote to the first page of Chap IV, p. 49 † Cf. Lecky, I, p. 352

‡ "Quicunque vult salvus esse, ante omnia opus est ut teneat Catholicam fidem; quam nisi quisque integram inviolatamque servaverit, absque dubio in aeternum peribit."—*The Athanasian Creed.*

number contained nothing that was pleasing to the Almighty, nothing that could ward off His sentence of eternal damnation. And yet it is a remarkable thing that the burnings, the tortures, the imprisonments, the confiscations, the disabilities, of which for many centuries the Church was guilty, were chiefly due to men whose lives were spent in absolute devotion to what they believed to be true, and whose personal characters have passed unscathed through the most hostile criticism.

Most religious systems seem to have originated, ultimately, in two moral sentiments which seem universally diffused through the human race; (1) the sense of *virtue*, which leads men to attach the idea of merit to certain actions they may perform, and (2) the sense of *sin*, which teaches men that their relation to the Deity is not that of claimants but of suppliants.* The two are in some measure antagonistic, but they probably co-exist in every religious mind, one predominating over the other, according to the prevailing political and intellectual circumstances of the age. The religion and philosophy of ancient Greece and Rome appealed most strongly to the sense of virtue;† there was an ideal of the majesty and dignity of human fortitude and self-reliance. On the other hand, Christianity appealed most strongly to the sense of sin: it emanated from a suffering people eminently endowed with religious sentiment; it reflected something of the circumstances that gave it birth; it was full of pathos, of humility, of emotion; it led its votaries to distrust their own powers, and to appeal to external help; its ideal was the absorption of manhood into God. Contrast the wonderful beauty of a Greek statue, in which the idea of excellence is blended with that of pride, with the painting of an early Christian artist, in which the dominant conception is self-abnegation and self-distrust. In the very early days of the Church, Christianity consisted much more of modes of emotion than of a reasoned belief in intellectual propositions, and it was not until about the third century that its moral sentiments were congealed and hardened into an elaborate

* Cf. Lecky, I, p. 354. † *ibid.*, p. 355

system of dogmas. But inasmuch as no dogma can possibly be an adequate, permanent, or faithful representative of a mode of feeling, the simple Christianity of the Founder suffered a set-back from which it has never recovered. The old attitude of self-distrust and humility was gradually transformed into pride and self-righteousness, and the doctrine of exclusive salvation was arrogantly put forward.

If an Institution, when once established, is to survive, to develop, and to become strong, it must frame a code of regulations and it must see that these are obeyed; and failure to obey must be followed by penalties of some kind. A State has its laws, a Church has its creeds. The State grades its punishments according to the seriousness of the offence. So in theory does the Church, but let the offence be the refusal to accept some dogma, no human punishment is great enough (though that will certainly be inflicted, if the age permits); the punishment must be the most painful that can be devised, and be eternal. Salvation is by way of the Church alone, and those who question the creeds must be expelled, their perpetual damnation being thus ensured.

2. "Suffer the little children to come unto me"

No proposition seems to be more self-evident or to be so immediately acceptable than that a man can be adjudged guilty of misdeeds only if he himself has had some actual share in their performance. One man's *misfortune* may fall upon another, but clearly *guilt* is entirely personal. It is therefore a remarkable fact that the conception both of hereditary guilt and of hereditary merit seem to pervade the belief and the institutions of all nations. In every early system of punishment which involved children in the destruction of a guilty parent, in the famous legend of the Fall, and in every hereditary aristocracy, the idea has prevailed that there is something in the misdeeds or in the merit of a man that must be reflected upon his descendants alto-

gether irrespectively of the latter's own acts. There seems, in particular, to be a period in the history of every nation when punishments involving the innocent child with the guilty parent are acquiesced in as a perfectly natural thing.

The genesis of this notion of hereditary guilt is obscure. In very early days men seem to have imagined that whenever they saw suffering they might infer guilt. They saw clearly that there was such a thing as transmitted suffering, and apparently they therefore concluded that there must be such a thing as transmitted guilt. Certain it is that the general conception of hereditary guilt was plainly expressed in the early dogmatic teaching of the Church. It was the unanimous belief of the Fathers that all who were outside the Church were doomed to eternal damnation, not so much on account of their own transgressions as on account of the transmitted guilt of Adam; even the new-born infant was therefore doomed unless and until baptism had united it to the Church.*

Precisely when infant baptism was introduced into the Church is doubtful, but it was certainly adopted in very early days both by the orthodox and by the heretics. It is universally said to be for "the remission of sins", and the whole body of the Fathers without hesitation pronounced that all infants who died unbaptized could not be saved. Some of the Greek Fathers, indeed, imagined that there was a special place assigned to infants, but the Latin Fathers maintained that hereditary guilt made descent into a place of torment inevitable. One theologian "doubted not there were infants not a span long crawling about the floor of hell".† Even **St. Augustine** (354–430), born a pagan but converted to Christianity at the age of thirty-three, one of the very greatest of the Fathers, declared that unbaptized infants descended into "everlasting fire".‡

Among the writings of the Fathers, there are few which so long possessed a greater authority than a short treatise *De Fide*, which is one of the clearest extant summaries of the Patristic faith. For a thousand years it was ascribed to

* Cf Lecky, I, p. 359 ff. † *ibid.* ‡ Cf. Lecky, I, p. 361.

St. Augustine, but it is now known to have been written by **Fulgentius** (*b.* 467). "Be assured," he said, "that not only men who have obtained the use of their reason, but also little children who have begun to live in their mother's womb and have there died, or who, having just been born, have passed away from the world without the sacrament of holy baptism, must be punished by the eternal torture of undying fire; for although they have committed no sin by their own free will they have nevertheless drawn with them the condemnation of original sin, by their carnal conception and nativity."*

It should be borne in mind that these Saints not only maintained that infants who had had but a momentary existence descended into eternal fire because of the eating of forbidden fruit by their legendary ancestor 4000 years before, but they also maintained that the creation and death of these infants were the direct and personal acts of the Deity.†

Nothing can be more deeply pathetic than the record of the many ways by which the terror-stricken mothers attempted to evade the awful sentence of their Church. Sometimes the baptismal water was sprinkled on the mother's body, over the womb; sometimes the still-born child was baptized, in the hope that the Almighty would accept the ceremony retrospectively; sometimes the mother obtained absolution and applied it to the benefit of the child. Despite priestly censures, such practices continued all through the Middle Ages, for the dreadful doctrine of the Church had wrung the mother's heart with agony that was too poignant even for that submissive age to bear.‡

The ultimate effects of the Reformation were very different from its immediate aims. Men's minds were awake, but only just awake. Ultimately this awakening was to lead to a new interpretation of the creeds in accordance

* *De Fide*, p. 70. See also St Isodore, *De Sentent.*, lib i, c. 22.

† Cf. Lecky, I, pp. 361–4.

‡ See Thiers' *Superstitions*, Chapter on *Baptism*, Lacroix *Le Moyen Âge*, Vol. I.

with the principles of universal religion; to lead to the judging of what is true and good, not by the teachings of tradition but by the light of reason and of conscience; to allow to become obsolete all doctrines which shocked men's sense of right. But the Reformers did not anticipate any of these things. Their avowed purpose was to construct a religious system (1) which should be as essentially dogmatic, distinct and exclusive as that which they assailed, but (2) which should represent more faithfully the teaching of the Early Church. The Reformers were divided into opposing sects, but in their new-born zeal both Lutherans and Calvinists went beyond the Roman Catholics; they emphasized the depravity of human nature and the consequential sentence of perdition; they emphasized the doctrine that the penalty due to original sin was "eternal fire"; they prescribed "eternal damnation" for the great majority of infants. The older doctrine of Catholicism, harsh and repulsive as it was, does not contrast at all unfavourably with this early Protestantism. The old Catholic doctrine of transmitted guilt was not only fully accepted but was emphasized by Protestants. In fact, nearly all the stress and energy of the new Protestantism flowed into a dogmatic channel. To Protestants the broad questions of morality were of little interest. Conscience was the last tribunal to which they would have referred as the supreme authority of their creed. For a long time the Protestant faith remained as much a blind unreasoning acquiescence, as did the faith from which it had broken away. The notion of transmitted guilt, and the associated doctrine concerning unbaptized infants, were not abandoned for more than another two centuries. The early Protestants were at least as hard, at least as merciless, and at least as vindictive, as any members of the Church of pre-Reformation days had been. If there was anything to choose between the two churches the new was less tolerant than the old.*

The scope of the doctrine of eternal punishment was not

* Cf. Lecky, I, 364 ff.

confined to unbaptized children; it extended also to all men and women outside the Church, and therefore to all pagans, and to all heretics; for, although their ordinary personal sins of commission and omission were readily forgivable the guilt inherited from Adam's Fall doomed them to inevitable perdition. Even in those very early days when the Christian Church formed but an utterly insignificant fraction of the community and at a time when almost all the members who composed it were themselves converts from paganism, the great majority of the Fathers deliberately taught that the entire pagan world was doomed to that state of punishment which they invariably described as undying fire. In any age and in any circumstances such a doctrine must seem inexpressibly revolting, but in those days every new convert must have readily, even rejoicingly, acquiesced in the eternal perdition of the mother who had borne him, of the father upon whose knees he had played, of the intimate friends of his childhood and early manhood, and of all those good and wise men who by their virtuous lives or precepts had first kindled a moral enthusiasm within his breast. All—mother, father, brothers, sisters, friends—were condemned to unquenchable fire, while he, the new convert, looked on, rejoicing. As for heretics, no matter how virtuous, how saintly the lives they led, they were reserved for the same fearful fate; it was rank blasphemy to talk of showing mercy to a man who had been guilty of "error". According to the favourite simile of the Fathers, the Church was a solitary ark floating upon a boundless sea of ruin. "No one," said **St. Augustine**, "cometh to salvation unless he is in the Church." "Hold most firmly," added **St. Fulgentius**, "and doubt not that not only all pagans, but also all Jews, heretics and schismatics who depart from this present life outside the Catholic Church are about to go into eternal fire."

Yet how easy it was to escape this dreadful fate: a few minutes devoted to a baptismal ceremonial would ensure enrolment as a member of the Church; nothing else was necessary.

How amazingly different the teaching of the Early Church was from the conceptions of the great teachers of antiquity, whose philosophies had at least been inspired by a bold and impartial search for truth. How different from the attitude of the great majority of educated men of the present age; do they not all find the highest expression of their belief (i) in the language of the prophets, who declared that the only service the Almighty required was a life of justice, of mercy, and of humility? (ii) in the language of the wise man who summed up our whole duty to consist in the fear of God and the observance of His commandments? (iii) in the language of the apostle, who described true religion as consisting of charity and of purity? (iv) in the language of the greatest Teacher of all, who assessed men's worth according to their acts and not according to their opinions?

The one prominent Reformer who unequivocally repudiated the doctrine of exclusive salvation was Zuinglius.* In a Confession of Faith which he wrote just before his death, and which marks an important epoch in the history of the human mind, he described that "future assembly of all the saintly, the heroic, the faithful, and the virtuous", "when every upright and holy man who has ever lived will be present with his God." In these days, when the mention of the doctrine of exclusive salvation seldom excites more than a smile, such language appears but natural, but when it was written it excited on all sides amazement and indignation. It drove **Luther** almost frantic. Mere virtue and mere saintliness a passport to heaven! Shocking.

"Suffer little children to come unto me, and forbid them not." Can those who expressly repudiated Christ's command—St. Augustine, Luther, Calvin, and the rest—claim to be *Christians*? If so, on what grounds?

* Cf. Lecky, I, pp. 373–84.

3. Predestination

Such a doctrine as exclusive salvation is so distinctly opposed to our natural sense of what is right and just, and to all the conclusions of those great teachers who worked out their rules of conduct according to the dictates of their own conscience and of what they felt to be morally right, that the doctrine is bound to establish a permanent opposition between dogmatic theology and natural religion. But all down the centuries to the time of the Reformation and beyond, the very outlines of natural religion seem gradually to become more and more obliterated, and dogmatic theology to become more and more developed. Theories of "predestination", commonly identified with Calvin, though they seem to have been held by St. Augustine, were really the natural developments of the previous workings on the mind of the doctrine of exclusive salvation. With these theories the greatest intellects both of antiquity and of modern days have struggled hopelessly; the problem involves such a maze of mutually destructive arguments concerning freewill and fore-knowledge, that the ablest metaphysicians have pronounced the theories absolutely untenable.

Consider some of the logically inevitable implications of the doctrine: we have to ascribe to the Deity a kind of justice and mercy entirely distinct from the same qualities as known to mankind, qualities which are utterly inconceivable because connoting acts which all men would term grossly unjust and unmerciful; we have to assume that guilt is entirely unconnected with personal responsibility; we have to recognize that millions of infants may be called into existence for a moment, to be cast into a place of eternal torment, and that vast nations may live and die and then be raised again to endure a never-ending punishment, simply because they did not believe in a religion of which they had never heard, or because the trivial crime of eating forbidden fruit had been

committed thousands of years before they were born; we have to be convinced that all this is part of an absolutely perfect and righteous moral scheme: we have to blot out those fundamental notions of right and wrong which the Creator has engraven on our hearts; we have to believe that the inner voice of our conscience is a lying witness. **St. Augustine** illustrated predestination by the case of a mother who had two infants. Each of these was but "a lump of perdition"; neither had ever performed a moral act. The mother overlaid one, it perished unbaptised, and therefore was cast into everlasting fire; the other was baptized and was saved. And we are bidden to believe that all this was *predestined by the Deity Himself*!

Said **Luther**: "It is the acme of faith, to believe not only that He is merciful who saves so few and who condemns so many, but also that He is just who at His own pleasure has made us necessarily doomed to damnation." * **Calvin** and his school were even more relentless: "The Fall, with all its consequences, was predetermined ages before the Creation and was the necessary consequence of that predetermination. The Almighty irrevocably decided the fate of each individual long before He called him into existence, and has predestined millions to His hatred and to eternal damnation. With that object He gave them being. He will hate them during life and after death He will cast them into the excruciating torments of undying fire, and will watch their agonies without compassion through the countless ages of eternity." †

Such teaching which makes the Deity the direct author of all sin, and subverts all our notions of justice and of mercy, is inexpressibly shocking and revolting. Yet for 1600 or 1800 years distinguished churchmen debated these matters, always seriously, and paying no thought whatever to the actual teaching of the Christian Founder. They were not engaged in sifting evidence; they had practically none to

* *De Servo Arbitrio*, esp. §§ 23, 24.

† See Calvin's *De Æterna Dei Praedestinatione*, and his *Institut Christ.*, lib iii, c. 21–3, and cf. Lecky, I, pp. 384 ff.

sift; they were just apriorists, engaged in metaphysical hair-splitting. They spent centuries in groping about for metaphysical truth, paying to real religion the very scantiest attention. Moral arguments did not appeal to them at all. They thrust their gentle Founder right into the background, and created a God that was inexpressibly ferocious and vindictive. It is not quite correct to accuse them of blasphemy, for they earnestly believed what they taught, and some of them would willingly have died in defence of their belief.

Every doctrine which is repugnant to the moral sense of thoughtful people of the present day excites an intense and ever-increasing aversion, but the older theologians invariably attributed to dogmas an intrinsic efficacy which was completely alien to this effect on the conduct of life. It must, of course, be admitted that a purely moral religion, appealing to a disinterested sense of duty and perception of excellence, can never be efficacious in an early semi-civilized condition of society. Stern negative commands as in Exodus xx. are imperative. If an early religion is to work at all, and if it is to attract attention and secure converts, it must become associated with innumerable ceremonies and with elaborate creeds and must be set in an ecclesiastical framework. All these accessories will eventually diminish in importance and perhaps fade away altogether, but in the meantime the moral side of religion is completely overshadowed by the doctrinal; men are taught that the present moral life cannot atone for error of belief and that guilt can be effaced only by the complete acceptance of the dogmas of the Church. It is a matter of great historical interest that, even down to the Renaissance times and beyond, certain notorious criminals have remained among the favourites of the Church because they professed to cling to her ordinances with full orthodox tenacity. By endowing a monastery, or by directing a persecution against heretics, they could obtain complete forgiveness for any crime they had committed. A famous case is that of **Benvenuto Cellini** (1500–71), the Florentine genius who was

painter, sculptor, goldsmith, engraver, and writer (his bronze "Perseus with the head of Medusa" is still unrivalled): but he was also a thief, a murderer, and was guilty of the most shameless immorality; but these crimes mattered little, for he professed to be a sound churchman and could therefore be forgiven everything: incidentally he included Popes and Cardinals in his circle of personal friends.* A much later story on record is that of a man of great wealth, who had been a notorious evil liver; he asked the priest who came to see him when he was gravely ill if his salvation could be secured by assigning half his wealth to the Church. The priest is said to have replied: "The Church cannot absolutely guarantee salvation, but I can assure you that the experiment you suggest is most certainly worth trying."

The combination of devotion and immorality, remarkable and repellent as it may now seem, was certainly not hypocrisy. The Church honestly believed that the one thing that really mattered was strict observance of its dogmas. A breach of that observance was absolutely unforgivable; but crimes resulting from mere human passions were of comparatively little importance, and they could always be forgiven, though the terms might, it is true, be a little exacting. Provided the faith of the Church was assiduously cultivated, a licence for the indulgence of passion could generally be purchased.

4. "Pious Frauds" and Credulity

The Fathers definitely laid down the principle that "pious frauds" were justifiable and even laudable.† During the Middle Ages the only scholars in Europe were priests and monks, who conscientiously believed that no falsehood could possibly be reprehensible if it conducted to the edi-

* See *Autobiography*, trs. by J. A. Symonds, and others. See also Lecky, I, p. 393.

† See Middleton's *Free Inquiry*, and Chrysostom's *On the Priesthood* See also Newman's *Apologia pro Vita Sua.*

fication of the people or was an advantage to the Church. Their writings were full of the wildest fables, some of them so grotesque and at the same time so audacious that they were the wonder of succeeding ages. The same men also taught, and with great emphasis, that credulity was a virtue and scepticism a crime. The indissoluble association of salvation with a particular form of belief produced the absolute indifference to truth and the boundless credulity that characterized the ages in which theology was supreme.*

The man who really loves truth cannot possibly subside into a condition of contented credulity. He will pause a long time before he accepts any doubtful assertion, he will carefully balance opposing arguments, he will endeavour to divest himself of every prejudice, he will cautiously abstain from attributing to probabilities the authority of certainties. When demonstration is impossible, he will adopt the belief which seems most probable; in fact, he will let the weight of probability decide.

For many centuries there had been no more fruitful topic of polemical discussion amongst the theologians than transubstantiation—the supposed change of the "substance" of the sacramental elements, bread and wine, at the moment of consecration. It was not disputed that the "accidents", the sense-qualities, of the elements remained unchanged; the elements preserved their weight, their appearance, their colour, their taste, and so forth, but the underlying "substance" in which all these qualities "inhered", became actually changed into the flesh and blood of the Founder of Christianity. Not only had the theologians not one shred of evidence to support their assertion, but they became violently indignant towards all who dared to question it; nay, more, to ask for "proof" was sheer gross impiety. They were not content to regard the sacrament as just a beautiful rite symbolical of the Last Supper; they insisted that there was a miraculous change, and that belief in that change was a vital test of the acceptance of Christian principles. To this day

* Cf. Lecky, I, p. 395 ff.

transubstantiation forms a great gulf, perhaps the greatest gulf, between Catholics and Protestants. The point of interest here is that the doctrine was adopted by the Church as a result of mere polemical discussion, and not as the result of any sort of scientific examination of any evidence supporting it. In recent years science has made such far-reaching discoveries concerning the inner nature of the substance of the 92 elements that it is no longer possible for any rational man to maintain that any such transformation can take place. There is no single scrap of evidence to support the doctrine. A thoughtful man is bound to ask himself, *how* and *why* such a change takes place when a particular formula is uttered.

In the seventeenth century an extraordinary diffusion of a truthful spirit was manifested both in the increased intolerance of what was false and in the increased suspicion of what was doubtful. The great secular philosophers of that century, seeing the " utter futility " of the old theological methods of wrangling about words, effectually destroyed the old modes of thought, not, however, by means of direct polemical discussion but by introducing a method of objective inquiry and a standard of scrupulousness incompatible with them. They taught men to regard credulity as discreditable, to wage an unsparing war against their prejudices, to distrust the verdicts of the past, to analyse with cautious scrutiny the foundation of their belief, and above all, to cultivate the love of truth for its own sake. The Englishmen **Bacon** and **Locke**, the Frenchmen **Descartes** and **Condillac**, all in their different ways, made experience the final test of truth: they curbed the exuberance of the theologians' imagination, they showed how grotesque were the wild fictions which had so long been received; they taught men to apply tests both to their traditions and to their emotions, tests which divested them of much of their apparent mystery; they introduced a love of impartiality and of free research. It was from the writings of those great seventeenth-century teachers that **Voltaire** (1694–1778), one of France's intellectual giants, " drew the principles that shattered the

proudest ecclesiastical fabrics of Europe", and it is therefore against these philosophers that the ablest defenders of mediæval theology have exhibited the most bitter animosity.*

If the old theologians condemned unbaptized babies to everlasting fire, what fate have they in store for Voltaire, the man who above all others so ruthlessly exposed them?

5. Why Churches Persecute

How the average small boy revels in such Old Testament stories as the massacres of Canaan and the slaughter of the priests of Baal! To him it all seems so just and so well deserved: the horrid peoples did not worship the same fierce God as the Israelites, *and ought* therefore to die. Baal worship, the religion of the Phœnicians and Canaanites, seems to have been a quite harmless kind of nature worship, carried out on the mountain-tops; but the small boy gets into his head that it was a kind of particularly wicked idolatry, and that the slaughter of its practitioners was not only fully justified but that it was the paramount duty of the Jews to effect it. The Levitical law was cruel indeed; "the man that doeth presumptuously, in not hearkening unto the priest that standeth to minister there before the Lord thy God, even that man shall die; and all the people shall hear and fear, and do no more presumptuously" (Deut. xvii. 12, 13). With such Biblical authority to follow, no wonder the Christian priesthood of later centuries were able to justify their own cruelties.

If an intolerant priest believes intensely that his own view of a disputed question is true beyond all possibility of mistake, and if he believes that those who adopt other views will be doomed by the Almighty to an eternity of misery,

* See, for example, De Maistre, *Soirées de St. Pétersbourg*, 6me *Entretien*, and *Examen de la Philosophie de Bacon*. De Maistre has been rightly called "the great apostle of modern Ultramontanism" His attacks on Locke and Bacon were waspish and childish, though not much worse than the attacks by the Tractarians, especially Newman, half a century later. How they all hated induction from observed facts (See Lecky, I, 402–8)

that man will probably do all he can to persecute. If you tell him of the great suffering which persecution produces, or of the virtuous lives of the victims, he will promptly reply that you are utterly incapable of appreciating the fundamental importance of the doctrine in question. And he will maintain that a heretic's religious worship, no matter how sincere, is an act so positively offensive to the Deity that it is a priest's bounden duty to suppress that act by every means in his power. Further, he can always point to the fact that in the great conflicts between argument and persecution the latter has almost always been triumphant. Persecution ruthlessly crushed the opposition to Rome of the Albigenses in southern France in the twelfth century: it brought about the dreadful massacre of the French Huguenots in France on St. Bartholomew's Day, 1572; it rooted out every vestige of Protestantism from Spain; and for a time it extirpated Christianity altogether from Japan; and it has done much the same thing in Russia, though for an entirely different reason. In short, it cannot be denied that persecution has exercised an enormous influence over the beliefs of mankind. When men are firmly convinced that the highest of all possible objects is to promote the interests of their faith, and that by the employment of force they can most fully attain that object, their persecution is likely to be ruthless. It would be unjust to impute sordid motives to them; they often honestly believe that they are acting as God would have them act. They say in effect, "The Church lays down exactly what you are to believe. Unless you do so believe, wholly and without reservation, you are a heretic, and all heretics must be punished. Inasmuch as heresy is the one great and unforgivable crime which man can commit, the punishment must be eternal damnation in hell." *

In the early Church and in the sixteenth century the official relations of the established religion to the State were based on the teaching of the Old Testament. The Levitical code was the first code of religious persecution that had ever

* Cf. Lecky, I, Vol. II, pp. 1–5.

appeared among mankind. It pronounced idolatry, for example, to be not simply an error but a crime, and a crime to be expiated in blood. **Jeremy Taylor** (1613–67), the English divine, in referring to this argument, clinchingly said that Christ, by refusing to permit his apostles to call down fire, like Elias, on the misbeliever, clearly indicated his separation from the intolerance of Judaism.*

6. Persecution by the Early Church

The Fathers were divided in opinion. Those who wrote when a pagan emperor was in power were the champions of toleration. Tertullian during the pagan persecution, and Hilary of Poitiers during the Arian persecution, strongly advocated the duty of absolute and complete toleration.† Even in the reign of **Constantine, Lactantius** asserted the iniquity of persecution, and some of the later Fathers, while defending the milder forms of coercion, seldom wished death to be the penalty of heresy. On the other hand the Fathers who wrote when the Church was definitely in the ascendency almost always inclined to persecution. From the very moment that the Church obtained civil power under **Constantine the Great** (270–337), the first Christian Emperor of Rome (it was he who assembled the first general council at Nicea at which Arianism was condemned and the Nicene creed was accepted), the general principle of coercion was adopted and was acted on both against the Jews, the heretics, and the pagans. In course of time the severity towards the pagans became extreme: they were deprived of offices in the State, their sacrifices were suppressed, and their temples were destroyed, though in remote country districts the peasants continued with unfaltering confidence to worship their old Gods.

The Father who was destined to consolidate the whole

* *Liberty of Prophesying*, § 22.

† See Milman's *History of Christianity* and Bayle's *Contrains-les d'entrer*. See Lecky, Vol. II, pp. 10–27.

system of persecution, to furnish the arguments of all its later defenders, and to give it the sanction of a name that long silenced every pleading of mercy was St. Augustine,* "on whom more than on any other theologian—more perhaps than even **Dominic** and **Innocent**—rests the responsibility of this fearful curse".

Augustine was one of the four great Fathers of the Latin Church and by universal consent the greatest of the four, more profound than his own teacher **Ambrose,** more original than his contemporary **Jerome,** and intellectually far more distinguished than **Gregory the Great.** The son of a pagan father and a Christian mother, he seems to have been the heir to very discordant passions. During his student days at Carthage, he gave way to the most unbridled licentiousness, and every Christian principle seems to have been absolutely alien to his nature. He adopted the most extravagant heresies, and such was his vast range of knowledge and such the splendour of his majestic intellect that had he decided an attack on the Christian Church the course of Christian history would certainly have been very different. However, he fell eventually under the influence of Ambrose, and after a severe intellectual struggle became a convert to Christianity. He was baptized at the age of 33.

The Church had gained a recruit at once formidable, masterful, and ruthless. No half measure for him. He made it his mission to map out with inflexible precision a complete theology. Impatient of doubt, he shrank from no conclusion, however impalatable; he seemed to exult in trampling human instincts into the dust, and in accustoming men to accept submissively the most revolting tenets. No one else had developed so fully the material character of the torments of hell; very few had dwelt so emphatically on the damnation of the unbaptized. He became the originator and the representative of the theology of intolerance. Religious liberty he emphatically cursed: "Quid est enim pejor, mors animae quam libertas erroris?"

* Cf. Lecky, Vol. II, p. 20.

Such was the power of his genius that Augustine completely overshadowed all his contemporaries, and it is a remarkable thing that his name was destined to become the watchword of the most opposing doctrines, the promoter alike of the best and worst sentiments of our nature. On the one hand, the Protestants drew their most powerful weapons from his teaching concerning predestination and good works; on the other hand, the Catholics saw in him a man typical of everything they held most dear—absolute rigidity of doctrine, exaltation of authority, ruthless punishment of opponents. And yet Augustine was curiously inconsistent in some ways; for instance he does not seem to have been a personally cruel man. He often exerted himself to save a man from the extreme penalty, and it is a little doubtful if he saw the far-reaching implications of his own teaching, though about these implications his followers had no doubt at all.

The rapid growth of monasticism during the latter half of the fourth century called into existence the monks, a body of men who, in self-denial, heroic courage, singleness of purpose, yet at the same time in merciless fanaticism, have never been surpassed. Often homeless wanderers and hungry, with no ties of affection, they had but one desire, and that was to further the interests of their Church; and to gratify that desire there was no suffering which they were not ready to undergo or to inflict. In their zeal they were absolutely merciless, and the writings of the Fathers convinced them that they were acting as true servants of God.

On the whole, the persecutions in those old days were not so violent as they were a thousand years later. Still, Patristic history contains some sanguinary patches. For instance, on one occasion during the reign of the Arian Emperor Valens, it is said that no less than 80 Catholic ecclesiastics were imprisoned in a ship at sea and treacherously burnt.

7. Catholic Persecution

After paganism had been suppressed in the Roman Empire, religious persecution was very rare for many hundreds of years Heresies hardly ever appeared. Catholicism seems to have correctly represented the intellectual needs of Europe. The social habits of the people, their laws, their studies, their very amusements, all grew out of ecclesiastical teaching, embodied ecclesiastical modes of thought, exhibited the same general tendencies. The spirit that radiated from the Church penetrated into all the relations of life. During the dark ages and the middle ages Catholicism was slowly laying the very foundations of modern civilization. There was no opposition: people all thought alike—so far as they thought at all. There has been nothing like it since until the present day when certain European nations, by persecution, by suppressing all opposing opinion, by broadcasting day in and day out, have converted their peoples into machines whose very thoughts are prescribed for them day by day. We are learning to recognize, however, that the machines are wonderfully efficient. But then, so, for similar reasons, was the pre-Reformation Church.

Catholicism aimed at a complete immobility, but the paralysis of the speculative faculties of intelligent men that can be brought about by the suppression of all critical spirit can never be permanent. As soon as the revival of learning commenced, intellectual life began once more to stir, and the human mind to expand. The Roman Church was quick to see the danger to herself and she at once employed all her great resources to impede the circulation of knowledge and to suppress the new liberty which men were beginning to demand for themselves. It was resolved that any kind of opposition must be suppressed at all costs. A new era of persecution commenced.*

Under Innocent III, Pope from 1198 to 1216, the power

* Cf. Lecky, II, 27–30.

of Rome reached its greatest height. He dared to exercise his papal jurisdiction even over the Kings of France and Spain, and all Europe seemed to fear him. Our own King John was a mere puppet in his hands. In 1208 he established the Inquisition, a dread tribunal which lasted for hundreds of years. In 1215 the Fourth Council of the Lateran enjoined all rulers to exterminate all those who were branded as heretics by the Church, and Innocent III had the audacity to threaten with excommunication and with the forfeiture of his dominions any prince who refused to extirpate heretics from his realm.* The general result was that for many centuries almost all Europe was inundated with blood which was shed at the direct instigation of the Church.

In short, more innocent blood was shed by the Church of Rome than by any other institution that has ever existed among mankind. The historian **Llorente,** who had free access to the archives of the Spanish Inquisition, assures us that by that tribunal alone more than 31,000 persons were burnt and more than 290,000 condemned to other punishments. At least 75,000 were put to death in the Netherlands alone during the reign of Charles V and his son. From the time of Dominic in the twelfth century to that of Torquemada in the fifteenth, and even long afterwards, there was a constant stream of victims, and altogether many hundreds of thousands must have perished. The very thought of some of the scenes enacted makes one recoil with horror. It was not as if the victims perished by a rapid and comparatively painless death. They were nearly always burnt alive. They were burnt alive after having suffered the most excruciating agonies that men well versed in the most diabolical methods of torture could devise. Not infrequently they were slowly roasted to death by a slow fire.†

It was not only that physical torment was thus inflicted on those who dared to exercise their minds in pursuit of

* See Rohrbacher, *Hist. de l'Église catholique XVII*, p. 220

† See Llorente, *Hist. de la Inquisition*, IV, also Eymericus, *Directorium Inquisitorum.*

truth, for what language can describe the feelings of mother, wife, sister or daughter who "saw the body of him who was dearer to her than life, dislocated and writhing and quivering with pain; who watched the slow fire creeping from limb to limb till it had swathed him in a sheet of agony, and when at last the scream of anguish had died away and the tortured body was at rest, she was told that all this was acceptable to the God she served, and was but a faint image of the sufferings He would inflict all through eternity." And this was brought about by a Church that called itself Christian! All that the victim had done was to dare to express an opinion of his own, probably to question some dogma that seemed utterly contrary to reason, certainly against all probability

It is not only that individuals were thus done to death after some semblance of a trial; we have also to remember that some of the most frightful massacres the world has ever known were instigated by the Church. The massacre of the Albigenses was instigated by a Pope. Another Pope actually returned thanks to heaven for the massacre of St. Bartholomew. For a considerable period, the spectators of every royal marriage in Spain were regaled by the public execution of heretics.

It should be borne in mind that the vast majority of the Church's victims were absolutely guiltless. It was all part of a vast conspiracy to check the development of the human mind, to reduce all men to one dead intellectual level. The saddest feature of the persecution was that it was done in the name of the Great Teacher who said, "By this shall all men know that ye are my disciples, that ye love one another." How justified was the answering taunt, "See how these *Christians* love one another."

8. Protestant Persecution

It is sometimes said that persecution was peculiar to the Roman Church, but this is very far from the truth. It may

be freely admitted that Protestant persecutions were never so sanguinary as those of the Catholics, but the general principle was affirmed quite as strongly and defended quite as pertinaciously by the Protestant as by the Catholic clergy.* In Germany, at the time of the "Protestation" of Spires, when the name of "Protestant" was assumed, the Lutheran princes absolutely prohibited the celebration of mass within their dominions. In England a similar measure was passed in the reign of Edward VI, and on the accession of Elizabeth, any religious service other than that of the prayer-book was prohibited under heavy penalties. Many Catholics were tortured and put to death. But the new English Protestant Church not only turned on their old enemies, the Catholics, they turned on all Protestants whose beliefs varied from those officially prescribed. For a long period the Presbyterians were imprisoned, branded, mutilated, scourged, and exposed in the pillory. Anabaptists and Arians were burnt alive. In Ireland, the Irish Protestant bishops denounced the religion of "papists" as heretical, and to tolerate it was a grievous sin. In Scotland, persecution by the Scottish Protestant bishops was ferocious; if a simple religious service was held by Dissenters privately in a house, the preacher was liable to be put to death; if in the open air both minister and people might incur the same fate. Scottish Presbyterians were hunted like criminals over the mountains; their ears were torn from the roots, they were branded with hot irons, their fingers were wrenched asunder, and the bones of their legs were shattered in the "boots"; multitudes were transported to Barbadoes, and soldiers were encouraged to exercise all their ingenuity in torturing them. In Sweden, Switzerland, and America, and elsewhere, all were branded "heretics", even "idolaters", simply because their beliefs were not exactly in accordance with the new Protestant dogmas.

The Romish persecutions were undoubtedly unrivalled in magnitude and were of an atrociously violent character, but, after all, the Romish Church, with a history of 1500 years,

* Cf. Lecky, II, pp. 39–54.

confidently put her faith in the principle of long-established authority; she was defending herself against innovation, and she could easily show how absolutely incompatible her doctrines were with the acknowledgment of the right of private judgment. On the other hand, the Protestant Church was a thing of yesterday, a Church that at once persecuted those who clung to the religion of their fathers, a Church that was by origin and profession the creature of private judgment, the logical exercise of which had, however, quickly broken her up into countless sects. Every one of these sects asserted its distinctive doctrines and all persecuted with the same virulence as the venerable Church from which they had all broken away.

Persecution amongst the early Protestants certainly was an indissoluble part of their theology and was enforced against even the most inoffensive sects, such as the Quakers. The Episcopalians generally justified it by appealing to Augustine, the Calvinists and Scottish Puritans by appealing to the Old Testament, but in all cases the dominating and controlling cause was the belief in exclusive salvation and in the guilt of "error". Each Protestant sect believed, with as much confidence as its parent church believed, that it alone found favour in the sight of God, that it alone was reserved for eternal bliss, and that all outside it were reserved for eternal damnation.

Is that belief quite dead yet?

9. The Birth of Toleration

Religious liberty owes as little to Protestantism, considered as a dogmatic system, as it does to Catholicism. Protestantism owes its birth to the Reformation, it is true, but the Reformation itself was due to the spirit of inquiry that followed on the Revival of Learning. Men woke up, began to ask questions, and to reason. They began to ask one another, why should any two of us, honestly holding

different beliefs, each charge the other with heresy? The new age gave birth to toleration, and persecution in the older sense gradually faded away. All the reformed Churches, Episcopalian and Nonconformist, are now showing an increasing willingness and an increasing flexibility to adapt themselves to the requirements of the age. The Catholic Church alone stands aloof, unfriendly as ever, stern, unyielding, and proud. She still believes herself right and all others wrong.

A French scholar of great distinction named **Castellio** * (1515–63), at one time a friend of Calvin, dared to repudiate the Calvinistic doctrine of predestination. He assailed it on the broad grounds of its repugnance to our sense of right. He maintained that the real object of doctrines is to make men better, and that those which do not contribute to this end are absolutely unimportant; that questions concerning the Trinity, or predestination, or the sacraments, are involved in great and perhaps impenetrable obscurity; and that to persecute men because of doubts about such things was not only absurd but atrocious. Both **Calvin** and **Beza** replied in a strain of the fiercest invective, and Calvin afterwards pursued Castellio with the grossest calumnies and with untiring hatred.

Castellio was the apostle of toleration.

It is to the continent and to France in particular, rather than to Britain that we must turn, if we wish to trace the results of the great rational and sceptical movement that stirred up the sixteenth and seventeenth centuries. As a nation we have never been famous for clamouring for indisputable facts and for coldly reasoning from them. How the typical Englishman hates mathematics and philosophy! How seldom we see him immersed in a really difficult problem. But a Frenchman? *he* does not want to see a newspaper expressing his own views, he wants to know what the other fellow thinks and says, though he may not improbably use picturesque language when he has found out. We had

* Cf. Lecky, II, 46 ff.

Bacon, Locke, Hume, and a few others, of course, but they appealed to foreigners far more than they did to us. The real stir came from France, and it is a curious fact that the first three of the French leaders represent three entirely different casts of mind. "The scepticism of **Montaigne** was that of a man of the world; of **Descartes** that of a philosopher; of **Bayle** that of a scholar."*

Montaigne (1533–92), surveying impartially the immense variety of opinions that were maintained with equal confidence by men of equal ability, arrived at the conclusion that it was simply hopeless to discover what was true; and that it was the duty of a wise man to remain poised with an indifferent mind between opposing sects. He emphasized the innocence of error and the guilt of persecution. **Descartes** (1596–1650), taught that the beginning of all wisdom is absolute universal scepticism; that all the conclusions of the senses must be discarded; and that the entire scheme of knowledge must be evolved from the simple facts of consciousness. The purely rational process by which scepticism was to be at last dispelled was altogether inconsistent with a system which stamped doubt a sin and which enforced conviction by fire. **Bayle** (1647–1706), possessed, to a remarkable degree, that rare faculty of assuming the acceptability of the system he was discussing, and of developing its premisses as if he were its most skilful advocate. He denied nothing. He affirmed nothing. He scarcely exhibited any sort of personal preference. But he brought forward the opposing arguments of discordant teachers, analysed them with the most exquisite skill, and developed them until they mutually destroyed one another. He did not *attack* the opposing systems. Like the two Kilkenny cats which were tied by their tails and thrown over a line to fight until each had eaten up the other and nothing was left but a few fragments of fur, so with two opposing systems of dogmas: Bayle had a veritable genius for effecting their complete mutual destruction, and then of illuminating, for all the

* Cf Lecky, II, pp. 57–64.

world to see, the vanity and even the nothingness, of the debris. Never was there such a book as Bayle's *Contrains-les d'entrer* for exposing clearly either the vanity of human systems or the disintegrating power of an exhaustive inquiry. He did more than any previous writer to break the spell which St. Augustine had so long cast over theology. He laid down as a universal axiom that the fundamental differences between right and wrong are so stamped upon the mind that they may be taken as the ultimate tests of all ethical teaching, and that no interpretations of a Divine revelation which violates them can be acknowledged as correct. "Sans exception il faut soumettre toutes les lois morales à cette idée naturelle d'équité qui, aussi bien que la lumière métaphysique, illumine tout homme venant au monde." And therefore Bayle concludes, "que tout dogme particulier, soit qu'on l'avance comme contenu dans l'Écriture, soit qu'on le propose autrement, est faux lorsqu'il est réfuté par les notions claires et distinctes de la lumière naturelle, principalement à l'égard de la morale."

Bayle maintained with great emphasis that if truth is to be discovered, a careful comparison of the opinions of opposing thinkers is absolutely essential, and that one of the most obvious consequences of persecution is to prevent such comparison. He vigorously protested against an abominable practice which presupposes a degree of certainty that simply does not and cannot exist and which is utterly repugnant to the dictates of the conscience.

Voltaire * (1694–1778), was still another eminent French thinker who helped to slay the persecuting dragon. "The spirit of intolerance sank blasted beneath his genius. Wherever his influence passed, the arm of the Inquisitor was palsied, the chain of the captive riven, the prison door flung open. Beneath his withering irony, persecution appeared not only criminal but loathsome, and since his time it has ever shrunk from observation and has masked its features under other names."

* Cf. Lecky, II, p. 67 *seq.*

The influence of Voltaire on French opinions was enormous but it is a gross fallacy to think that because Voltaire attacked dogma that therefore he attacked true religion. As Mr. Alfred Noyes * says, if Voltaire did not accept the Mass it nevertheless represented for him a "profound impulse of self-annihilation before the Supreme Being". Voltaire, speaking of Jesus, said, We do nothing He did, and He announced nothing of what we believe. He never said in the Gospels: I am come and I die to extirpate original sin; my mother is a virgin; I am consubstantial with God; I have two natures and two wills, and yet I am but one person." But Voltaire urged, "Let us worship the Supreme Being through Jesus, since it is so established among us." What Voltaire really hated was Church dogma: "religion consists of virtue, not the impertinent balderdash of theology". Listen to these lines which he wrote:

> "Un jour, tout sera bien, voilà notre éspérance;
> Tout est bien aujourd'hui, voilà l'illusion.
> Les sages me trompaient, et Dieu seul a raison.
> Humble dans mes soupirs, soumis dans la souf-
> france,
> Je ne m'élève point contre La Providence."

There was admittedly much rancour in Voltaire's character, but there was sweetness too. Voltaire did more than any man for religious toleration.

The general result was that toleration in France grew apace, but to the Church religious liberty was anathema. That the Church became despondent may readily be seen from a pronouncement of Gregory XVI (Pope 1831–46): "We arrive now at another most fruitful cause of evils, with which we lament that the Church is at present afflicted; namely, indifferentism, or the pernicious opinion which is disseminated everywhere by the artifice of wicked men, according to which eternal salvation may be obtained by the profession of any faith, if only practice be directed by the

* *Voltaire.*

rule of right and uprightness. . . . From this noxious fountain of indifferentism flows that absurd and erroneous opinion, or rather that form of madness, which declares that liberty of conscience should be asserted and maintained for everyone; which most pestilential error, some with the utmost impudence have extolled as beneficial to religion. But what is more deadly to the soul than the liberty of error?" * Thus even as late as 1832, what a man *thought* was the thing that really mattered; of what little importance was "the rule of right and uprightness"!

The spirit of toleration rapidly spread from France to England. Though in some ways inconsistent with the tenets of Protestantism, toleration is the inevitable consequence of the due exercise of private judgment. When men have appreciated the countless differences which the exercise of that judgment must necessarily produce, when they have estimated the intrinsic fallibility of their reason, when they have acquired that love of truth which a constant appeal to private judgment at last produces, they will never dream that guilt can be associated with an honest conclusion, or that one class of arguments should be stifled by authority. The English Protestant divine, **Chillingworth**, drew with an unfaltering hand the line between certainties and probabilities, eliminating from theology the old conception of faith considered as an unreasoning acquiescence.† **Jeremy Taylor** believed that the great majority of theological doctrines cannot clearly be deduced from Scripture and that it is therefore not necessary to hold them.‡

The power of consigning heretics to death was withdrawn from the Church in 1677.§

The object of the persecutor was to prevent free inquiry. Until the seventeenth century it was a "sin" to study with equal attention and with an indifferent mind the writings and the opinions on both sides of a religious question; it was a

* Bull delivered at Sta. Maria Maggiore, on the Feast of the Assumption, 1832.
† *Religion of Protestants* ‡ *Liberty of Prophesying.*
§ Cf. Lecky, Vol II, pp. 80–1.

"sin" to resolve to follow the light of evidence wherever it might lead; it was a "sin" to remain poised in doubt between conflicting opinions; it was a "sin" to give only a qualified assent to indecisive arguments; it was a "sin" even to recognize the moral or intellectual excellence of opponents. All these things theologians stigmatized for centuries as offensive to the Almighty and absolutely unforgivable. A priest might grant full absolution to a man for life-long breaches of every moral law, but if he deviated by a hair's-breadth from any single prescribed dogma of the Church, eternal damnation awaited him.

10. That Place of Torment: Where is It?

We need not try to differentiate between the Hebrew *Sheol* and the Greek *Hades* (ᾅδης), the Greek *Tartarus* (τάρταρος) (2 Peter ii. 4) and the Greek *Gehenna* (γέεννα). We are concerned here with the conception of hell as commonly held by the Early Church and the Mediæval Church, for in this conception there is hardly any ambiguity at all. In the hell as thus conceived, eternal punishment is never-ending, and there were those who maintained that the joys of the blessed were enhanced by the sight of the sufferings of the damned. This monstrous view is actually found in the works of **St. Thomas Aquinas**, as well as in the writings of Protestant divines. The eternal pains of hell are conjectured to be both physical and spiritual, the latter consisting chiefly of the torments of despair and remorse. The earlier churches were often decorated with pictures representing the souls of those who had just died as actual bodies writhing with horrible contortions in a literal fire. The old theologians were not content to condemn a heretic to this sort of punishment for twenty years (a maximum term for a criminal sentenced by the present laws of England), or even for a hundred years, or even for a thousand years, or even for a million years: the punishment was for all eternity, and the

soul was *never* to be finally consumed: in some marvellous way the fire stopped short of that. It was a special kind of fire that never died out and never consumed finally!

All down the ages the actual locality of hell has naturally excited the greatest attention. The sun is sometimes conjectured to be hell, and the sun-spots to be the scenes of the devil's greatest activity. The conjecture has this advantage that there is a fair amount of space (the surface area is ten thousand times that of the earth, and the volume is a million times that of the earth) available for the vast numbers of heretics which the eternal-damnation theologians have consigned to it, and the sun is likely to remain a fiery furnace for thousands of millions of years to come. But the commonest opinion, which was sanctioned by St. Thomas Aquinas, is that hell is at the centre of the earth. We are gravely told that the condemned have to "descend" into hell, and as this must apply to every part of the earth's surface, the various descents must converge on the centre. The scientific difficulties against the acceptance of this particular conjecture—the difficulties of space, the gravitational and dynamical difficulties of a hollow shell, the replenishment of fuel for the æons of time that hell is to last, and the like—did not worry the theologians at all, for, as they said, "God will provide".

We are told there is to be a final adjudication by the Deity of the billions of human beings, "the quick and the dead" who have ever lived. As there is to be an adjudication, and not a mere announcement of verdicts already arrived at, each case will presumably be separately considered, and the whole trial must last a very long time. Even if the time taken up is only a single minute per person, millions of years must elapse before the adjudication is completed. But the real point of interest is this: We can imagine that vast number of human beings arranged in a line according to the degree of moral excellence of their lives on the earth, the greatest saint being at one end and the greatest sinner at the other. Now clearly the difference in merit between any two adjoining

neighbours would be absolutely inappreciable, and yet *somewhere* in that line a division is to be made, those on the one side to be awarded eternal bliss and those on the other to be consigned to eternal damnation! And if the old-time theologians get their way, the decision of the Deity will be determined not by what men did but by what they thought.*

It seems to follow that the number who escape punishment will be very few indeed. For are we not all, every one of us, heretics? If we are members of one Christian Church, we are heretics in the estimation of the other Christian Churches, and every Christian Church seems to claim to find special favour in the sight of God.

The conception of hell is not only atrocious, it is in the highest degree immoral. The misery which untold millions of people have suffered as the result of the intense fear which the Early and Mediæval Churches instilled in their minds is a sad reflection on Christianity as an institutional religion. It was Augustine who was largely responsible for giving the Christian religion a character of passivity, of drowsy devotion, and of blind obedience; for engendering a disposition and even a passion for worshipping its object in return for security offered. There is nothing more reprehensible in the whole history of Christianity (and that is saying much) than this shocking idea of striking a bargain with the Deity. One thing the Reformation did was to make thoughtful men abandon the sentimentality, the weakness, and the dejection of the older teaching of the Church, and to inaugurate a glowing aspiration for a manly, joyous, and world-renewing Christianity which would give up the jealous God of the Old Testament and substitute a God of love.

* See also Chap. XIII, § 4.

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2. *The History of Christianity*, H. H. Milman.
3. *Free Enquiry*, Conyers Middleton.
4. *Contrains-les d'entrer*, P. Bayle.
5. *Histoire critique de l'Inquisition d'Espagne*, J. A. Llorente.
6. *Le Moyen Âge*, Paul Lacroix.
7. *Voltaire*, Alfred Noyes.
8. *De Spectaculis*, c 30, Tertullian (A D. 150–220).

   [Tertullian openly professes his delight at the prospect of seeing the infidels in the lower regions: "How shall I admire, how laugh, how rejoice, how exult, when I behold so many proud monarchs groaning in the lowest abyss of darkness; so many magistrates who persecuted in the name of the Lord, liquefying in fiercer fires than they ever kindled against the Christians; so many sage philosophers blushing in red-hot flames with their deluded scholars."]
9. *History of Europe, Vol. I, Appendix*, H. A. L. Fisher.

(See also references in the footnotes.)

CHAPTER XII

Theism: the Creeds of the Christian Churches

1. First Notions

Here are three from a selection of conundrums asked by intelligent young people:

1. *Theism* implies belief in the existence of God; *Atheism* implies a denial of the existence of God. Is it theism or is it atheism to maintain that the ruler of the universe is that strange being who, bent on murder, met Moses and his wife at an inn? (Exodus, iv. 24).

2. " God is love."—What does the word " is " mean? Presumably " God " is a concrete term and " love " is an abstract term. Does the statement " God is love " imply that the two terms are interchangeable? Can the concrete be dissolved completely into the abstract?

3. On what grounds do the Churches say that those religious opinions which they approve have all been revealed to them by God, and that those religious opinions which they do not approve have all been suggested by the Devil?

Such questions cannot be brushed aside. They have to be answered. And how can we rebuke even the twelve-year-old boy who on being told that the Bible had been inspired by God and that the whole of it must therefore be believed, rather scoffingly replied as he pointed to the first chapter of Genesis, " Oh, Sir, surely you do not want us to believe what our grandfathers believed—that the earth was created

as recently as 4004 B.C., and that the whole business was finished off in six days?"

Whatever ideas about God we may ultimately feel constrained to adopt, we must certainly eliminate from our minds and from the minds of our children those primitive notions of what God is supposed to be like, notions which we have inherited from more child-like ages when the Bible was accepted in all its literalness, when people thought of God as an elderly autocrat, a sort of almighty Kaiser, a savage tyrant, stern and inflexible, jealous and mean, encouraging his favourites to engage in enterprises which could seldom be defended on grounds of either morality or justice.

We may safely ignore the primitive and impossible God of the earlier part of the Old Testament. The distinctive and valuable elements of the later Jewish belief in God are to be found in the writings of those great reformers of the Hebrew religion, the Prophets—Amos, Hosea, Isaiah, Micah, Jeremiah, and Ezekiel—a succession of great teachers who asserted with compelling earnestness the reality of God. These teachers were not metaphysicians but virtuous men of profound moral insight, and what they wrote we must read as literature, and not as philosophy. It was the God of these great prophets that, some centuries later, Christ accepted as the Supreme Reality.

Does God exist?—It is of little use to debate this question unless we form some preliminary idea of what is signified by the *word* God. We must have in our minds a positive conception of some kind. The word as just a word is useless. A tentative and provisional conception is that of a powerful spiritual Being, whom Jesus called " Our Father which art in heaven ". Such a conception is necessarily very vague. However, it gives us a start. Can it be accepted or must it be denied?

Briefly, can the existence of God be *proved*?

To this question there is a very definite answer: there is *no proof* of the existence of God.

The Theist asserts; the atheist denies; the agnostic

does not know; the sceptic is doubtful. Four men, bearing these respective labels, may personally be of irreproachable character, they may all be Christian in the best sense of that ambiguous word, and yet each of them may purposely falsify the meaning of the terms which do not apply to himself, in order to throw stones at his three opponents. And it is sad to relate that, of the four, the theist is often the most uncharitable.

Although there are no " proofs " of the existence of God, certain arguments are often advanced which are supposed to point to the *probability* of the existence of God. We shall give an outline of these, but it may be useful first to give some explanation of two frequently used theological terms, " transcendence " and " immanence ".

The word " transcend " means to overtop, to surpass (*trans*, over, across; and *scandere*, climb). It suggests a " climbing up " to a level which will give us a greater view than a view which can normally be obtained by the senses. In philosophy and theology " transcendent " and " transcendental " connote something which is not an object of possible experience; it is something which is quite unrealizable in experience, something of an *a priori* nature, something dug out from the dark recesses of the mind, something which admits of no sort of verification. The term " immanence " (*in-manere*, to dwell in, to remain) is used in contradistinction to transcendence; it connotes an " indwelling " of some kind. A transcendent creator is conceived to be separate and distinct from the creature or thing He creates, to be a Deity having an existence apart from the universe He creates, the universe being merely a subsidiary expression of his activity. But the doctrine of immanence conceives the Deity to pervade the whole universe itself, His existence and activity being expressed solely by the unrolling of the natural cosmos; in other words, Immanence conceives the Creator and the created to be an indivisible unity.

Both terms, transcendent and immanent, are dangerous terms to use because of their ambiguity; their connotation

is so vague that different writers often use them in different senses, and even the individual writer may be guilty of the same thing, unconsciously guilty it may be, but guilty nevertheless.

2. Arguments for the Existence of God

(i) The Argument from General Consent

The word "cult" (Latin *cultus*, worship) is a useful neutral term to denote all acts and words of a magical, or religious, or magical and religious, nature; it embraces all the means by which man has ever sought to get into touch with the unseen world.

Not the least remarkable result of historical and archæological research is the discovery that cult is a universal feature of all human societies. No nation or tribe has ever been known to be entirely destitute of all idea of religion. Even in races of the lowest stages of savagery, cult is familiar and dominant, and it can be traced back to the remotest times. And it is a curious fact that there is a remarkable similarity in different forms of cult; they all seem to represent impulses very deeply rooted in human nature; they also seem to indicate that man has tried to approach the powers of the unseen world in ways which are largely identical. In particular, that form of cult which is termed sacrifice has always been widely prevalent. Man always seems to have had a *fear* of some unseen Power, and to have felt the need of propitiating it.

When once an unseen Power greater than man himself is assumed to exist, man naturally has a desire to put himself in right relation to that Power, and this desire may correctly be termed his religion. Such a desire is clearly quite independent of the vast variety of beliefs which have been held in regard to the *nature* of the Power.

In view of this universality of belief in the existence of an unseen Power, may we infer that the belief is necessarily

true? The answer must be in the negative. The belief is the outcome of mere feeling, and the grounds for such belief are therefore necessarily unconvincing.

(ii) The Argument from the "Still Small Voice"

All men seem to have an instinctive feeling of what is right and what is wrong; this moral sense tells them what they *ought* to do; they are conscious of a moral obligation. A "still small voice" directs them. Can we draw any kind of theistic inference from such facts of conscience?

That many men are sometimes stirred by deep religious feeling it is idle to deny, and on such occasions they are convinced that the feeling is in some sense divine in its origin. Some of them believe that another Person is actually present. "The other Personality could speak to me in words clearly enunciated but without sound." Newman himself said that God "is to me supremely and luminously self-evident". The proof of *religion* lies in these spiritual experiences of the individual, and such proof is unassailable.

But although the moral sense is authoritative in its commands, we are not logically justified in inferring that the commands are infallible and Divine. The moral sense cannot afford us an absolutely sure criterion, for it is only an instinct and has to be guided by reason. Moreover, the moral sense differs widely amongst different peoples and in different ages. It is true that every instinct points to a reality of some kind, but there is no justification for inferring that the reality in this case is divine, that the insistent "still small voice" is the voice of God. "The fact," says Professor Pigou, "that under the immediate spell of an experience men are forced psychologically to adopt a particular theoretic conclusion is not a proof so cogent of that conclusion that it can be proclaimed *a priori* irrefutable. Even the most religious men, when their moments of inspiration have passed, and ordinary men throughout the main part of their lives,

will hesitate before the paradox that in the sphere of religion alone, unlike any other sphere of knowledge, criticism and analysis are wholly irrelevant." Men's religious experiences differ enormously and fundamentally, and when carefully analysed and compared and subjected to criticism, no inference can legitimately be drawn from them concerning the existence of God. We cannot say that they point to more than a very slight probability that the voice of conscience is the voice of God. Nevertheless we must remember that religious inquiry must always begin from the facts of *religious experience*, not from dogmas about God: from the immanent, not from the transcendent.

If we attempt to ascribe the fact of conscience to inherited instincts, obviously the explanation merely pushes the problem one stage farther back. If we argue that the fact of conscience is of Divine origin and that *therefore* God must exist, the argument is of the most worthless scholastic type. But if we can discover some other means of establishing the probability of the existence of God, we can legitimately make *that* a basis for arguing that the inward light we call conscience may be a divine gift.

(iii) The Ontological Argument

Let the reader turn down the light, sit back in his easy chair, half close his eyes, and allow his imagination to run riot. A sort of cinematographic phantasmagoria may float before his eyes, as if limned by a score of artists and squeezed out of a score of colour-tubes. Now let him rouse himself, seize upon a part of that fantastic picture, assert that he has conceived it, call it a concept, and announce to the world that corresponding to the concept there must be a "reality". Let him make that reality—the reality which he himself has created—the foundation of a metaphysical system. It need hardly be said that, at the very first touch of a critic's hand, such a system is bound to collapse, inasmuch as the major premiss from which all subsequent inferences are drawn

consists of a mere figment of the imagination and has no relation whatever to the reality it feigns to be. This method of building up metaphysical systems on a foundation of fictitious realities dug out of the imagination, and having no relation to any sort of objective experience or verified facts, is apriorism naked and unashamed. And yet the apriorist, who sometimes claims that his ideas derive their sustenance exclusively from that " inner light ", dares not only to snub the man who may take endless trouble to ascertain his facts and to verify them, but also to call him a " mere empiricist "!

" Ontology " (Greek *ὤν*, being; *n.pl.*, *τὰ ὄντα*, existing things) attempts to arrive at conclusions concerning the nature of " reality ". Stored away in the ontologist's mind are ideas derived from different sources—from books, from scholars, from everyday experience of the world around him; and from these ideas he attempts to divine the nature of the unknown reality which " underlies " " appearances "; for instance, of " substance ", of " the soul ", of " God ". It was *the* method of the mediæval Schoolmen, and is still the method of the few surviving metaphysicians of the last century.

The ontological argument concerning the existence of God starts off with some sort of mental *idea* of God and from that idea attempts to infer the *reality* of God. St. Anselm put the matter thus: " The human mind, somehow, finds itself possessed of the idea or concept of a perfect Being, that is, God. But a perfect Being must be an existing Being, for existence is an essential part of perfection. Hence the existence of God is a necessity of thought."—Such a statement, which is quite typical of Scholasticism, makes a modern philosopher despair; it is so utterly vague, inconsistent, and nonsensical. Note, in particular, the utterly irrational conclusion, following the word " hence ". Yet it is typical Scholastic reasoning.

It was too much even for Kant, the greatest of Germany's many famous thinkers, though himself leaning strongly towards apriorism. He tore to ribands the ontologist's argument.

The ontologist conceives God as the "totality of reality" and concludes that such a Being must exist *because* the existence logically and necessarily follows from the mere conception. This is, of course, rank pantheism. How can such a conception yield a God "who is a purposive moral being capable of distinguishing between good and evil and of siding with the former"? If the claim were put forward as an *hypothesis*, it would perhaps be worth considering seriously, but it is gravely put forward as an a priori *proof*! And how could such a God be an *all-perfect* Being? The "totality of reality" necessarily includes all human beings, all of them admittedly *im*perfect, and therefore rendering imperfect the all-inclusive Being. No mere analysis of human conceptions can possibly solve such a problem.

(iv) The Cosmological Argument

Cosmology is concerned with the *a priori* discussions of the philosophical problems about the universe (κόσμος) as it exists in time and space. It seeks to find a First Cause.

The small boy is constantly asking *why*? Some phenomenon strikes him as an effect, and he wants to know its cause. "Why has the clock stopped?"—"Because I forgot to wind it up," replies his father. And that simple explanation may suffice. But as he gets older he wants to know the explanation of the explanation, and he may pursue his chain of inquiries until answers become difficult or impossible. This sort of follow-up is, of course (so it has been flippantly said), the besetting sin of all philosophers and scientists.

"A violent ring of the bell startles the servant; the servant treads on the dog's tail; the dog jumps against my chair; I drop the sugar-tongs into my coffee; the dropping of the sugar-tongs is followed by a splash; the splash is followed by a coffee-stain on the tablecloth. It is usual to say that the stain is 'caused' by the splash, the splash by the dropping of the sugar-tongs, the dropping of the sugar-tongs by the movement of the dog, and so on until we get

back to the cause of the ringing of the bell. Any one of the sequence of actions might be selected as being the cause of the coffee stain, but as it is customary to select that action which seems to be the most immediately followed by the particular change to which attention is drawn, we say that the coffee stain was caused by the splash. The *action* of the splashing is the *cause*; the *change* from a clean tablecloth to a stained tablecloth is the effect." *

The cause of a cause is the cause of the effect. The universe is a continuous series of changes, and in this continuous series we may take any section we please, and call the first change in this isolated section the cause of all or any that follow; the last, the effect of all or any that have gone before. But in the continuous series the actions stretch backwards as far as we like to take them.

That every effect has a cause is a universal belief derived from experience. The belief seems coercive, and its truth certainly reaches a very high degree of probability. That "like causes under like conditions always produce like effects" is a principle sometimes put forward as an axiom, but the principle certainly cannot be applied to regions which never come within the range of finite experience.

In the theory of causation, philosophic doubt centres mainly on the nature of the *connexion* between cause and effect. Schools of thought differ fundamentally about this. Is the connexion just a sequence, and nothing more, or is there something of the nature of a *tie*? Does the effect just *follow* the cause, or does the cause *enforce* the effect? *That* is the unsolved problem. Certain it is that if the mind is restricted to passive observation, it fails to detect any sort of *necessary* connexion. But then the mind is quite incapable of observing *pure* facts; it seems, as it were, to project something of itself into every observation it makes, and it is quite possible that the idea of necessity and enforcement supposed to be the essential factor in causation is exclusively a contribution of the mind's own.

* See the chapter on *Causation* in the Author's *Science and Theology*.

The cosmological argument for the existence of God is sometimes put this way: The cosmos must have had a beginning, therefore it must have had a cause and this First Cause must be conceived as God. The argument is the natural result of the human craving for causal explanation.

Creation is sometimes looked upon as an event which took place at a definite date in the past, to which we can in thought return by a temporal and causal regress, say at twenty minutes past nine on Monday, 31st May, 4004 B.C. But inasmuch as we have long ago abandoned the geocentric hypothesis, inasmuch as we now know so well that our little earth-world is an insignificant microcosm in the universe, inasmuch as the astronomer can actually see the birth of new worlds and the death of old ones, why should we attach any importance to the beginning and end of the solar system—an utterly trivial event in the history of the universe as a whole? Even if we consider the idea of creation of the whole universe as a special event that took place at a definite date, we are then driven to think of God as a pre-existent, self-centred Person to whom in His untroubled eternity the idea of such a creation suddenly occurred. The universe thus appears as from a magician's wand, and God looks on as a spectator of His own drama, perhaps interested, perhaps not. Such an absurd conception is unworthy of a place in serious religion. To think of God as a transcendent Being becoming bored with His own eternal calm and devising a sort of new game to kill time—is not the idea at least a little impious? Professor Pringle-Pattison reminds us of the old gibe of the Epicureans, familiar in Cicero's day, provoked by the anthropomorphism of the creation idea: "How did God occupy Himself before He created the universe, and how did He come to fix upon the particular date of creation?"

This pathetically solitary pre-creation figure is a survival of primitive anthropomorphic picture-making. God is represented as a sort of much-magnified man rarefied to mere mind, existing by Himself, with no sort of relation to anything else. How childish it all seems!

It is impossible to conceive of God being reached at the farther end of a chain of physical causes and effects. We cannot think of Him as one more phenomenon added to the series. As **von Hartmann** says (*Philosophy of the Unconscious*), "Contentment with the regress to a God-creator is the true mark of speculative indolence;" and **Schiller** (*Must Philosophers Disagree?*): "We cannot assume that, because parts of the whole are 'caused', the whole must be. Causal inquiry, therefore, provides no way to a serviceable God."

(v) The Teleological Argument

The Teleological argument is sometimes referred to as the "Argument from Design" (Gk. τέλος, end fulfilled, design, purpose). It is based on the evidence of purpose or design in nature, the assumption being made that if design is once established we are bound to admit the existence of a Designer. Since the argument is based on facts of the physical world, it is also known as the physico-theological argument.

The idea of purpose implies both an intention of *doing* something and a conception of some kind of *plan* for achieving it. Purposive activity is admittedly the central feature of our human experience.

The teleologist maintains, then, that the universe was planned. He is in direct opposition to the mechanist who maintains that the universe is just a chance arrangement of atoms put together by blind force, and might equally well have been one of an infinitely large number of other possible arrangements. If an ape sits down at a piano and strikes a succession of chords, he *might* by chance eventually hit upon some famous piece of classical music; if he sat down in front of a printing machine, he *might*, straight away, by chance set the type of some great literary work, say the Bible. But we all know that the chance of these things being done is so remote that even to suggest the possibility seems

absurd to the last degree. For the same reason we rule out a chance-made universe. The basic question at issue lies between intelligence and absence of intelligence, and we cannot bring ourselves to believe that rationality emerged from a chance-made atomic grouping. Teleology infers from the appearance of purpose the existence of creative mind The emergence of mind in the course of evolution requires for its full understanding the idea of *guidance* or *direction* in evolution.

But a good deal of controversy has ranged round the doctrine of evolution and the argument from design. Some have maintained that the doctrine shatters, others that it strengthens, the argument. **Haeckel** had maintained that **Darwin's** *Origin of Species* favoured the "mechanical" origin of living nature, but this was challenged even by his own friend **Huxley**.* In the general controversy the human eye has often been made the favourite illustration. As **Pringle-Pattison** says, the human eye certainly suggests the idea of special contrivance more forcibly if we look simply at the complex and delicate mechanism of the perfected organ than if we view its structure as something gradually evolved, through countless intermediate ages, from the pigment spots which serve some of the lowest organisms to distinguish light from darkness. But this gradual fashioning is certainly not to eliminate teleology; and surely the eye is a long long way from perfection yet; otherwise why do we find the microscope and telescope so useful?

Mill has attacked the eye-problem from a different angle: all the parts of an eye act together to enable an animal to see, and this is the only circumstance that they have in common. The concurrences are too numerous to be due to mere chance; therefore they must arise out of a common cause. This cause must be *connected* with the common effect, sight, to which all the concurrences contribute. But, the fact of sight is subsequent, and not precedent, to the collocation of operating elements. Therefore it must have been the idea

* See Huxley's "Kitchen-clock" Argument in his *Darwiniana*, pp. 110–11.

of sight, wherein is implied a purposing mind, by which the collocation was caused.*

Professor Haldane objects to the view that evolution has been guided by divine power, firstly because most lines of descent end in extinction, and this hardly suggests the work of an intelligent designer; and secondly because a very large number of originally free-living lower animals have evolved into parasites and have become the source of misery and pain to other animals and to men: did God make the tapeworm? If He did, what is the ethical explanation?—Professor Haldane asks these and other questions.†

Dr. **Schiller** reminds us that teleologists are apt to ignore the heartrending evolutionary failures, deep-seated evils, and stubborn frustration, "this widespread dysteleology" as **Haeckel** called it. They ignore these things because they allow themselves to be hampered by out-worn theological dogmas—"that the divine power is unlimited and the divine purpose *known* (and yet also unknowable!)". On what grounds do we call God omnipotent? "Every indication of design in the cosmos is against the omnipotence of the Designer. Wisdom and contrivance are shown in overcoming difficulties, and there is no reason for these in a Being for whom no difficulties exist. The author of the cosmos must therefore have worked under limitations; he was obliged to adapt himself to conditions independent of his will." "The teleological argument leads only to a *limited* God, who adapted means to ends and operated teleologically. The adaptation in the finite world can never prove the operation of an infinite God, only the power and wisdom of a Being adequate to bring them about."

And why should we crave for a still greater Being? Consider just three of the things He has designed:

1. *The atom.* Let the reader consult a few leading modern

* Mill's *Essays on Religion*, pp. 171–2 See Professor Pigou's *The Problem of Theism.* Pigou is critical of Mill's argument.

† For his answers, see his *Causes of Evolution*, pp. 159–60.

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works on atomic physics and then try to construct a model of one of the heavier atoms, that marvellously complex thing with shell after shell of its constituent electrons all placed in position, a model say the size of a cricket ball, which he can easily manipulate. Now let him try to imagine the model as a machine in actual motion, the parts moving with incredible speeds. Then let him try to imagine the model shrink to the size of the smallest visible particle of dust, the machine as a machine still running, and with undiminished speed. Lastly let that tiny machine shrink and shrink and shrink until it is a millionth of its dust-particle size, but still running, and all its parts prepared to run on, if not interfered with, for æons of time.—What an amazing design!

2. *Man himself*. Still full of imperfections he undoubtedly is, but think of him a hundred million years ahead. Even now, what an amazing design!

3. *The Universe*. As we have already pointed out, our sun is one of a hundred thousand million stars in a single galaxy, and the galaxy is only one of a hundred thousand million galaxies already known. Again, what an amazing design!

If we admit the existence of God at all, we are compelled to think of a Being so powerful and intelligent as to be utterly beyond our comprehension. *Nevertheless it is altogether irrational and wholly unnecessary to call Him "omnipotent"*.

3. Conclusion from the Five Arguments

A rigorous "proof" compels the assent of every normal man, and since there is a large number of perfectly sincere atheists and agnostics as well as of theists, all equally capable of thinking rationally, obviously no "proof" of the existence of God is possible. There are only two classes of propositions which seem to compel assent: (1) those which rest on the

evidence of the senses; and (2) those which are deducible from universally accepted axioms But the former class depends upon the belief in the uniformity of nature, and in view of the necessarily insufficient induction, this uniformity cannot be completely demonstrated; and the "axioms" referred to in the latter class are *never* the self-evident truths they claim to be: in recent years even the hoary axioms of Euclid have been successfully assailed. Hence the truth of both classes of propositions is never more than an affair of probability, greater or less. Inasmuch as, however, any possible "proof" of the existence of God stands quite outside both classes of propositions, the inherent doubt in these, usually very slight, of course, is of no consequence in the principal matter now under consideration.

How are we to weigh up the five arguments? The evidence (the use of the word is scarcely legitimate, perhaps) cannot be weighed and measured, cannot in any way be considered mathematically or scientifically. It is bound to react on differferent minds differently. To Professor **Pigou** the evidence provides "a slight *prima facie* probability" of the existence of God, and it seems impossible to do more than pronounce a verdict in terms of probability of some kind, seeing that certainty is so entirely out of the question. To myself the first four arguments carry very little weight, the third none at all. But the fifth, the argument from design, seems to carry a weight that is simply irresistible, because from it we seem to be compelled to draw an inference which carries with it an extremely high degree of probability. I cannot bring myself to believe that the universe is merely a chance-made affair.

Faith, and nothing more? I think not. In balancing such probabilities, it is essential to suppress the emotions and not to surrender to them. Faith may perhaps be allowed to step in as a supporter after the main thesis has been established, but not before. What is faith? Said Lotze, "Faith supplies the satisfying and convincing conclusion of those upward soaring trains of thought which reason itself began." I dis-

trust those "upward soaring trains of thought" when trying to solve a problem. That way originated all the Scholastic puerilities. And what are we to think of St. Paul's definition,—"Faith is the substance of things hoped for, the evidence of things not seen?" What does St. Paul mean by the *evidence* of things not seen? Faith is really a self-surrender to feeling, and if we deliberately suppress the reason and give our emotion free play we shall certainly fail to provide the present generation with an acceptable solution to their religious problems. We are no longer living in a static sentimental age. The intelligent half of the present generation are dynamic; they demand facts, though they are easily persuaded to weigh probabilities, and it is therefore not impossible to convince them of the existence of God. This conviction must, however, be intellectual, not merely emotional.

No doubt 300 years ago the words of the Authorized Version (Heb. xi. 1), which we quoted above, may have conveyed to English ears fairly accurately what St. Paul really meant, but after such a long period there is bound to be ambiguity and uncertainty if thoughts are expressed in the same language. Language changes. The Revised Version runs: "Faith is the assurance of things hoped for, the proving of things not seen," and this does seem to represent more nearly the meaning of the Greek, ἔστιν δὲ πίστις ἐλπιζομένων ὑπόστασις, πραγμάτων ἔλεγχος οὐ βλεπομένων. So varied is the connotation of the English word *faith*, that one would like to find a better translation of πίστις; perhaps *belief* is a little nearer to what St. Paul meant. The word ὑπόστασις is certainly more correctly translated metaphorically by some such word as *assurance* or *confidence* than by the more literal term *substance*. As for ἔλεγχος, the translation *evidence* is decidedly misleading; so is the word *proving*; the word *test* is far preferable. Thus Heb. xi. 1, may be read something like this: *Faith means the assurance of things hoped for*; *it is the test of things not seen*. Faith begins when reason ends. Truths and ideas which first come to us on the authority of others *must* be passed through the crucible

of our own experience; there must be personal verification before we can win full assurance and triumphant certainty. Such assurance can never be given by theological dogmas; men cannot live spiritually on theological theory.

In the words of the hymn, " We have but faith, we cannot know ", there is too violent an antithesis. No doubt faith may be described as " a leap into the dark ", but it would be folly to take the leap unless the jumping-off ground were first fully tested.

4. What is God Like?

As the existence of God is an hypothesis admitting of no sort of verification, it seems futile to attempt to visualize Him or to assign to Him any kind of attributes. So indeed it is. And yet all through the ages it has been the custom of religious teachers to describe Him in terms suggesting that their knowledge was *certain*, and not merely inferential and derived from premisses of extremely doubtful validity.

The *metaphysical* conception of God as an " Absolute " is an intellectual conception, a reasoned-out conception; " it is an Identity which holds multiplicity together and makes it intelligible "; " it is a Unity which includes but does not transcend the differences which it somehow holds in solution ". The *religious* conception of God is entirely different. It turns away from the metaphysician's Absolute and endows God with a personality; it makes Him a Spirit amongst spirits, a Spirit which can be loved and worshipped; it conceives Him as a God to whom men can pray, who takes sides, who has purposes and preferences, who maintains personal relations between Himself and those whom He has created. There is clearly a great chasm between the conception of the intellectual metaphysician and that of the mystical theologian, but many great religious teachers, Christian and non-Christian alike, have attempted to bridge the two conceptions, even to fuse them; examples are the

Greek philosopher **Plato**, the Christian apostle **St. Paul**, and the Patristic theologian **St. Augustine.** It is important to remember that both conceptions, the immanent and the transcendent, are alike in this respect: they are entirely speculative and hypothetical.

Archbishop Temple crosses the chasm by means of a bridge constructed in this way: God may properly be conceived as the absolute sum of all possible values which are gathered together in a supreme good. But a thing which is good must be real, and if good is to be made effective and operative there must be a vitalizing principle of will or purpose. There must therefore be personality. Hence we feel compelled *to pass on* from the thought of God as only a sum of values to the thought of Him as a living person, or at least as a Being in whom personality is a constituent factor.—Admittedly such a bridge is necessarily very, very frail, but it does seem to go some little way towards solving our problem, though the stern metaphysician will probably adhere to his Absolute on the one side of the dividing chasm, and the simpler devout mystic to his man-made Spirit-friend on the other. The metaphysician will always demand intellectual satisfaction: the religious man will always ask for a Person with whom he can commune. Yet they both look wistfully across the bridge, the metaphysician from his icy friendless region stretching backward to a misty infinity, the theologian from his highly-coloured region of anthropomorphism; but both of them wondering if there is a stronger foothold on the other side.

Anthropomorphism, the conception of God in man's own likeness (Gk. ἄνθρωπος, man, μορφή, form) will probably never be uprooted from the minds of simple people, who feel it a paramount necessity to visualize God in *some* way; and how are they to do it unless they think of the little child's God—" a big strong man up above the bright blue sky "?

It was reported in the London newspaper Press from Warsaw in November, 1936 * that a priest had been arrested

* See e.g. *The Observer* for November 15.

by the police in Kiszyniew, Bessarabia, " for selling seats in heaven ". " He had a ' map of heaven ' on his desk, with allotments portioned out and numbered. Simple-minded peasants, mostly women, used to come to his house and select a position on the map. The places which were ' near God ' cost double the normal price. Those near the Archangel Gabriel were a little less. Ordinary places cost a sum equal to two English pounds. Many peasants sold their last cow to obtain a place. When the affair was discovered the priest had sold about 200 places."

The story tends at first to give us something of a shock. But how are we to know what theological views that rustic priest may have sincerely held? In any case the priest's morality is not in issue here. The point of interest is this: is the anthropomorphism of those peasants any cruder than that of the vast majority of all the less well-educated sections of the peoples of Europe, and America, including, say, 80 per cent or 90 per cent of Britons.

As **Professor Joad** says, it is a matter of agreement that an anthropomorphically conceived deity is a degraded deity. The conception has, of course, come down from remote antiquity and, even now, people by no means unintelligent are apt to think of God as an enlarged and ennobled edition of themselves. Very naturally they desire to visualize Him, and what other picture can they paint? though why so many still picture Him as a super-human despot, not only desiring to be propitiated by sacrifice but also threatening punishment on all who displease Him, it is hard to see. A personal desire for *self*-sacrifice in some righteous cause is quite a different thing.

Theologians have always recognized that religion may be justly charged with the insufficiency, even the absurdity, of anthropomorphism, and for this reason they have striven to obtain from philosophers ideas that might lead to a more generally acceptable conception. But they have always shrunk from a total surrender of transcendence and a whole-hearted adoption, in its place, of immanence. They have

striven to fuse the two, but how? To abandon transcendence is to abandon Personality, and this means forfeiting all clearly conceivable qualities and all the effective energy of God, with the consequential loosening of religious bonds. The ontologist's cold impersonal Absolute lifts religion out of the circle of presentations and especially out of the circle of the interests of the human individual. How is man to worship an abstraction?

That our ideas of God are so confused and vague is not surprising if we bear in mind the sources from which we have derived them—from the nursery, from Hebrew prose and poetry, from Greek philosophy, from Patristic theology, from Scholasticism, from the great religious painters, from Milton, from modern philosophy, and even from the Athanasian creed. How can such a medley be fitted into a single picture?

An exclusively immanent God is no more acceptable than an exclusively transcendental God. Anthropomorphism does at least give us a personal God, a God with a will, a God with a purpose, a God that can love. But the Absolute? What are we to make of "a static God, resting in solitary perfection and bliss, an emotionless spectator of the creation drama, the embodiment of truth, beauty, and goodness in an impersonal Being co-extensive with the Universe?" Words, words, words, empty words. There seems to be no possible means of applying, in any way whatever, the term "personal" to the Absolute. To personality we are bound to attribute will, power, and purposive intelligence, and how can these attributes be applied to a metaphysical abstraction?

If then God is neither transcendental, anthropomorphic, personal; nor immanent, absolute, impersonal; how are we to think of Him? Can we fuse the two conceptions? Can the chasm between them be bridged, as Archbishop Temple suggests?

5. The Infinite

Certain words like *immense*, *incalculable*, and *immeasurable* have long been debased by popular usage from their original meaning of " unlimited " or " without end " into meaning merely " the very large ". A single member of that word group retains something of its original meaning, viz: the word *infinite* (Lat. *in*, without; *finis*, end; *finitus*, bounded), and even the word infinite, except when correctly used by mathematicians, has come to have the vague meaning of something merely very big. Now it is quite true that when the mathematician begins to count he can keep on adding units indefinitely; it is impossible to bring such a series of numbers to an " end ", and we may rightly say that the series is " infinite ". But the numbers are merely abstract numbers and we *cannot conceive the infinite series to apply to any form of reality*. The numbers of stars which the unassisted eye can see at any one time are easily counted and never exceed 3000; the number of hairs on the human head rarely exceeds 50,000 or 60,000; it is easy to count the number of grains of sand placed in a line an inch long, and therefore to estimate the number in a cubic inch and therefrom the number of grains in a layer a foot deep covering the earth's surface. It is a simple matter to estimate the number of grains of sand that would be required to fill the whole of the visible universe. Such numbers are immensely large; it would be impossible to count them, even if counting were rapid, in such a period as a billion years. But few people realize that these numbers, huge as they are, afford *no conception whatever* of an infinite number. *We cannot get nearer the infinite by making vast additions to the finite.* Except to the mathematician, the term *infinite* is an absolutely meaningless term, and it is folly to use it. If it is suggestive of anything positive at all, it is that of utter human helplessness in attempting to conceive the inconceivable. To infer the infinite from the

finite is as gross a fallacy as inferring the unknowable from the known. in fact it is the *same* fallacy.*

" Infinite " is clearly an unmeaning term when applied to realities of any kind, and, inasmuch as God is a Reality, we cannot conceive Him except as a *finite* God. Why, indeed, should we try? If we think of the universe as created or evolved by His will, why should we seek evidence beyond what is adequate for the purpose? The universe is vast indeed, probably much vaster than we even suspect. Even so, we are compelled to think of it as *finite*. How could we ascribe to an *infinite* Deity either personality, or consciousness, or power, or purpose? All those things depend on limitation. Personality rests on the distinction of one person from another, and an all-embracing person is an unmeaning phrase. Since an all-embracing person would necessarily include all sinners as well as all saints, how could we attribute moral perfection to an infinite God? Good and evil would be indistinguishable. Again: power is a finite conception which is applicable only to a finite world in which force implies resistance, and it is power only when it overpowers what resists. How could it be infinite if anything resisted it? Once more: since an infinite God could have neither personality nor consciousness, how could we ascribe to such a God either intelligence or wisdom? " impersonal intelligence " and " unconscious wisdom " are meaningless terms.

We call God " Almighty ", thereby ascribing to Him infinite power. But if He were Almighty, how could He remain a cold dispassionate observer of human suffering and sin? Only if we regard God as a finite God can the function of pain and the nature of evil be in some measure understood.

Since man can only know God through His works, can we think of Him as an eternal Spirit, immanent in all His works as well as transcendent above them?—Only very, very vaguely. That bridge across the chasm between the philosopher and the theologian is, as we have seen, exceedingly frail. And yet a bridge of some sort there presumably must be.

* Cf. Chap. VIII, *Space and Time*.

Any religion which is to succeed amongst the masses cannot render God "too human". If the personality of God is completely lost, all may be lost, for what then could explain the universe to the unlettered man? Rather than dissolve religion entirely in the metaphysician's pantheistic Absolute, surely it is preferable to assert the *personality* of God as something inexplicable and incomprehensible. The weighing up of probabilities seems definitely to tilt the scale in that direction. Whatever attributes we ascribe to God are necessarily wholly hypothetical and speculative. But it must nevertheless be borne in mind that an exclusively transcendent personal God is as wholly incomprehensible and as defiant of our reason as is an immanent impersonal God. Theologians have long been aware of the weakening of religious foundations by the retention of an anthropomorphic Person possessing infinite powers, and they are now laying more and more stress on the immanence of God and His superpersonal attributes; but they still have a very long row to hoe, and in ground where the Christian church's creeds are very deeply rooted.

The religious man may, however, safely say, and with profound conviction:

I BELIEVE IN GOD

but if he is wise he will be content to think of all the possible attributes of God with reverent agnosticism, for of those attributes *we know nothing at all.* Our reason is in no way offended if we say that by faith in God we mean the conviction that Power and Love and Purpose are characteristics of ultimate reality.

6. "Jesus, the Christ"

"What think ye of Christ?" That question was first asked nearly 2000 years ago, and it is being asked still.

Let us carry ourselves back a few hundred years to a time before the appearance of the newspaper press, even before the invention of printing, and think of an intelligent

young working man making his appearance in some quiet fishing village, say the then Whitby or Brixham; talking to the simple local fishermen, telling them stories, sometimes preaching to the small crowds which gathered around him, occasionally performing feats of healing, not infrequently crossing the path of authority both lay and clerical, always leaving behind him profound impressions, both on those whom he attracted and on those he repelled, and gradually being talked about throughout the whole country. All sorts of rumours would spread amongst the superstitious country folk, wonder upon wonder would be ascribed to the newcomer, and eventually authority would deem it wise to suppress him. Even after his death he would remain a perennial topic of conversation, and as story after story passed on from mouth to mouth they would certainly lose nothing in the telling. Some thirty or forty years afterwards it might occur to some enterprising person that the whole story of the life of the young man would make an interesting book, and he would try to track down a few people who had either known the young man or had at least known others who had known him. What would those now elderly fishermen remember with certainty? Every incident of the long-ago would probably be greatly magnified; every one of the stories the young man had told and of the talks he had given would, of necessity, after such a lapse of time be falteringly and very imperfectly repeated. It would be too much to hope that the book would be anything like a faithful record of the actual happenings it professed to relate, and future readers would be likely to have a difficult time in sifting the wheat from the chaff, though they might arrive at some partial truth by comparing this with other records that would almost certainly be made.

Of quite humble origin, the young man Jesus followed his father's trade, that of a carpenter. He was a Jew who had been brought up in the Jewish-Syrian-Greek environment of northern Palestine. His native tongue was Aramaic, but he could certainly read Hebrew and must have known

something of Greek, and it is certain that he had studied the writings of the great religious teachers of his race. His intelligence and his natural ability were evidently of a high order, and he expressed himself in his own language with great skill and lucidity. As a preacher he must have made a very strong appeal. With highly educated men he was able to hold his own easily, and those who dared to engage him in wordy warfare soon discovered they had met their match.

He led the life of a missioner, and did not shrink from carrying his message to the viler sections of the peoples amongst whom he lived; in fact, he cheerfully endured the greatest hardships and spent much of his time amongst outcasts. But he had little reverence for any constituted authority which fell below his own high standard of honesty, sincerity, and rectitude, and it thus came about that he was hated as well as feared. His ruthless exposure of ecclesiastical and clerical pretence eventually led to his death.

He seems to have had a deep sympathetic insight into the troubles of others, physical, mental, and spiritual, and he was unquestionably a highly skilful psycho-therapist, as we should now call him.

Jesus was no philosopher; he was a poet and a preacher. Above all, he was a social reformer, an enemy of oppression, of worldly pride, of snobbery. He was the friend of "publicans and sinners". But we must always bear in mind that he was an Oriental, and that in preaching he sometimes used Oriental paradoxes and hyperboles. It is probably for this reason that the gospel teaching seems sometimes to be contradictory.

Historians seem to be in general agreement that in Jesus we have an overwhelming personality, unique, unparalleled, and apparently unfathomable.

The trouble is to get at the real facts concerning Him. Until recent years, Christians generally believed that Jesus "came down from heaven" "to save mankind". It made no difference whether they "knew" this from the Bible, as the Protestants taught, or from the Bible interpreted by the Church, as the Roman Catholics taught. All agreed that

Christianity was a divine revelation contained in an "inspired and infallible book". But during the present century the Bible has been subjected to minute historical criticism; it has been treated like any other ancient record. Research now shows clearly that a good deal of it is legendary, and that many of its "facts" are inaccurately recorded. This is almost bound to be so when, for instance, we think of the origin of the records concerning the life and work of Jesus. These records were made by no master hands, but by untrained men strongly biased towards the records they made, and it is not improbable that some of them were influenced by the stories of the "Saviour-Lords" of the older mystery religions. No new religion can hope to come into its own without assimilating something of the traditions of the old religions it is displacing. There can be no doubt that after the crucifixion the very name of Jesus attracted to itself most of the outstanding conceptions of greatness and divinity current at that age, and that astounding claims were made on His behalf by men who had known Him personally or by others who had known such men. Thus much is certain. But how many of His recorded acts and sayings will ultimately be proved to be absolutely authentic? We cannot yet tell.

Meanwhile, men's views differ. (1) Some men still hold the traditional view that Jesus was God's "son" who "came down from heaven", played the part of a working man for a time, and then went back again. (It will be remembered from the Old Testament that God himself is occasionally said to have assumed the form of man and to have appeared for a brief time on earth, as when he appeared to Abraham; and numerous stories of the old Greek gods doing the same thing will occur to the reader). (2) Some men think of Jesus as a fanatic whose dominating idea was an early catastrophic last day and judgment. (3) Some men lay main stress on the *teaching* of Jesus; they look upon him as a man born into the world like all other men but who became the "Son of God", much as we all become sons of God, though he in a preeminent degree. (4) Some men regard Jesus as having been

a quite commonplace prophet, who counted for little; (5) Some men deny that he existed at all.

How do we really stand? Perhaps it does not matter much. It would be idle to deny that the amazing influence of Jesus will endure as long as humanity exists, and that He will remain the central figure of history. His Personality baffled the analysis of the Greek philosophers, and it has ever since challenged the understanding of the greatest scholars.

Was He God or was He man? Orthodox teachers have nearly always been anxiously occupied in safeguarding His divinity, and have almost forgotten His humanity. *Why?*—Was He not one of ourselves, despite His amazing personality?

7. The Parentage of Jesus

All theologians admit that Jesus had a human mother, but not all of them admit that He had a human father. This parentage dispute can be considered independently of the incarnation. If the virgin birth be denied, it by no means follows that the incarnation must be denied.

In approaching this subject, the reader should bear in mind that a miraculous birth has been claimed for many others besides the Founder of Christianity; for instance, Buddha, Zoroaster, Lao-Tsze, Mahavira, Pythagoras, Plato, Lysander, Alexander, and even Augustus Cæsar! To understand the origin of these stories it is of prime importance not only to understand the early history of certain human institutions but to detach ourselves from the prepossessions of our own times and country and to live with the peoples of distant lands and distant ages.*

* To read the 12 volumes of Frazer's *Golden Bough* is a formidable task, but it is well worth doing. At the very least the two volumes *Adonis*, *Attis*, *Osiris* should be read; they throw much light on the point now in question. It is shown clearly for instance, that the stories of virgin mothers are relics of an age of childish ignorance when men had not recognized the intercourse of the sexes as the true cause of offspring. Even in later times, when people were better acquainted with the laws of nature, they sometimes imagined that miraculous beings may be born in miraculous ways by women who have never known a man In Palestine to this day the belief survives. See *Adonis*, &c , Vol. I, p 264 *seq.* There are, of course, innumerable stories concerning carnal commerce between gods and human women and between goddesses and human men. See Frazer, and the many authorities he quotes.

The sole authority for the claim that Jesus was born of a virgin are the statements in the first and third Gospels, Matthew i. 18–25, Luke i, 34, 35. The two narratives are, however, irreconcilable. St. Luke's story of the return to Nazareth after the Presentation in the Temple is quite inconsistent with St. Matthew's account of the visit of the Wise Men, the murder of the innocents, and the flight into Egypt. Moreover, able critics have held that the Lucan verses are a mere interpolation, and all scholars agree that the early chapters of St. Luke come from another source than the rest of the Gospel. As for St. Matthew, we know for certainty that this Gospel was not written until about forty years after Jesus was crucified. Many literal-minded persons have sought support from the "prophecy" of Isaiah (vii. 14, 16), but it is well known that the words "a virgin shall conceive and bear a son" were wrongly translated from the so-called Septuagint, and actually, no virgin birth is asserted. In short, there is nothing in the Bible to support the virgin birth except * the two quoted Gospel passages, and the great majority of competent scholars shrink from attaching to either of them any importance whatever. St. Mark never mentions the doctrine. Neither does St. Peter, and assuredly he must have known, if any disciple knew. Neither does St. John, for whom the "Sonship" of Jesus had no sort of connexion with His physical or local origin.

But what of the evidence on the other side, viz.: that Jesus was the son of Joseph, Mary's husband?

1. The two genealogies given by Matthew (i. 1–16) and Luke (iii. 23–38) carry back the descent of Jesus *through Joseph* to David. Their sole aim is to prove that Jesus is the son and descendant of David *through Joseph*, and they would be absolutely meaningless and useless if Joseph had not been the father of Jesus according to the flesh. Further, St. Peter

* St. Paul does *not* assert the virgin birth, in Gal. i, 4, as is sometimes said, in the phrase *γενομένον ἐκ γυναικός* ("born of a woman".) The word *γυνή* (wife) must be distinguished from *παρθένος* (virgin). Cf. I. Cor. vii, 34, *μεμέρισται ἡ γυνὴ καὶ ἡ παρθένος*.

speaks of Jesus as being a direct descendant of David (Acts. ii. 30), so does Paul (Acts xiii. 22; Rom. i. 3).

2. Locally, Jesus was certainly looked upon as the son of Joseph. "Is not this Joseph's son?" (Luke iv. 22). "Is not this the son of Joseph, whose father and mother we know?" (John vi. 42). "Is not this the carpenter's son?" (Matt. xiii. 55). "Jesus of Nazareth, the son of Joseph" (John i. 45). "His parents went to Jerusalem every year" (Luke ii. 41). "The parents brought in the child Jesus" (Luke ii. 27).

3. Mary certainly recognized Joseph's fatherhood. "His mother said unto him, Son, thy father and I have sought thee sorrowing" (Luke ii. 48). (In this connexion it is interesting to note that the words *espoused wife* (Luke ii. 5) and *betrothed* (R.V.) are now known to be incorrectly re-edited terms for *wife*; Joseph travelled with his *wife* (not his betrothed) when she was "great with child".)

Amongst the numerous arguments sometimes advanced in *support* of the hypothesis of the virgin birth, two are worth mentioning:

1. Argument based on the genealogies in Matthew and Luke.—It is argued that the real significance of these genealogies lies in the fact that they guaranteed our Lord's legal position as a descendant of the royal house of David. The Roman and Jewish laws legitimatized all children born in wedlock, whether the husband was the real father or not. We may therefore, it is argued, take advantage of this law to assert that, although Jesus was not the *actual* son of Joseph, he was the *legal* son of Joseph, and therefore a son of the royal house of David to which Joseph himself indubitably belonged.—Comment on such an argument is best avoided: it would be difficult to keep within the bounds of reverence.

2. Argument based on embryology.—It is argued that because parthenogenesis (παρθένος, virgin, γένεσις, production), i.e. the development of the ovum without fertilization by a spermatozoon, is known among certain lower forms of life and can be artificially induced in a small number of lower

animals, that it *may* once have taken place in a woman. If then we assume that all immoral tendencies are inherited exclusively from the father, we may argue that none of these can be transmitted by a virgin mother, and that she may therefore give birth to a sinless son.—The first and most obvious answer to this argument is that the virgin mother must, if we assume the truth of the main premisses, herself have inherited immoral tendencies from her own father. Really, however, the argument is not worth a moment's consideration. The main facts of embryology and heredity are now so well known that science regards the argument as utterly childish. Mammalian parthenogenesis is absolutely unknown to biology.

Briefly, the hypothesis of a virgin birth may be finally abandoned. There are no more jealous guardians of the Incarnation than the Roman Catholics, and one of their most distinguished writers has said, "This doctrine (of the virgin birth) has no essential connexion with the Incarnation, for Christianity has no wish to explain the Incarnation in pagan fashion as the result of a commerce between a divinity and a woman."* In the Biblical text, "God so loved the world that he gave his only begotten Son," who would dare to accept the term "begotten" literally? But what an unfortunate metaphor!

The former Dean of St. Paul's, Dr. Inge, says: "No evidence except that of the mother can ever have been brought in favour of it. If, then, we believe it, we must consider that it falls somehow within the order of probable events. Suppose now that a biologist were to introduce the case of Mary of Nazareth into a scientific discussion of parthenogenesis, or that a barrister were to appeal to it in a paternity case, what would be the feelings of the Christian public? The majority would be simply astonished, the minority would be angry and shocked. But why?" †

* Tyrrell, *Lex Orandi*, pp. 172, 174

† *Truth and Falsehood in Religion*, p. 94 The carefully reasoned view of a highly intelligent and well-informed woman, Miss Maude Royden, may be seen in her letter to *The Challenge*, Feb. 22, 1918

It is often forgotten that the clauses concerning our Lord's birth were not included in the creeds to emphasize his divinity but, on the contrary to emphasize the fact that he had a real human body and that he was born and that he died as a *man*, a fact which the Docetic teaching denied, and the denial was therefore proclaimed by the Church as a heresy.

The best-known biblical scholars of the day differ widely amongst themselves, but it is possible to see in their writings the general drift towards the same carefully reasoned view—that Jesus was fully man with human needs, emotions, and thoughts, who spent nights in prayer to God, and sometimes felt profound depression, as in Gethsemane. "Jesus of Nazareth, a *man* approved of God among you," said St. Peter, "ye by wicked hands have crucified and slain," (Acts ii. 22, 23). Who can fail to be deeply moved by that last despairing human cry, "My God, my God, why hast thou forsaken me?" Oh, the pathos of it!

8. The Incarnation

All Christians attribute divinity as well as humanity to Jesus. What does this mean?

Jesus taught that all men are sons of God. "Be ye therefore perfect even as your Father which is in heaven is perfect." (Matt. v. 48). "Call no man your Father upon earth, for One is your Father which is in heaven" (Matt. xxiii. 9). "Our Father which art in heaven" (Luke xi. 2–4). Man possesses a nature which is essentially moral and spiritual; he is therefore partaker of the Divine nature and thus shares in the Divine sonship. When Jesus declared, "Whosoever shall do the will of God, the same is my brother and sister, and mother" (Mark iii. 35), he evidently regarded himself as sharing in the Divine sonship which is common to all men. When St. Luke traces back the human descent of Jesus to Adam, "the son of God", he clearly indicates that

Jesus shared in this Divine sonship which is common to all mankind.

Jesus himself made no sort of claim to be the son of God in a *physical* sense, such as the narratives of the virgin birth affirms, or in a *metaphysical* sense as is required by the Nicene theology. He claimed to be God's son in a *moral* sense, in the sense in which all human beings are sons of God.

Jesus never claimed Divinity for himself. Never in any critically attested sayings is there anything which suggests that His conscious relation to God was other than that of a man towards God—the attitude which He wished that all men should adopt towards God. Jesus was in the fullest sense a man, as much so as any other human being; he had not merely a human body but a human soul, intellect, will. Many of the earlier Greek Fathers, e.g. **Irenaeus** and **Athanasius**, obviously thought of him simply as the Logos of God residing in a human body.

The Divinity of Christ does not imply the virgin birth or any other miracle; nor does it imply omniscience.

The late **Dean Rashdall** said: "If *divine* and *human* are thought of as mutually exclusive terms, if God is thought of as simply the maker of man, if man is thought of as merely a machine or an animal having no community of nature with the universal Spirit who is the cause or source or 'ground' of the existence alike of nature and of other spirits, it would be absurd to maintain that one human being, and one only, was both God and man at the same time. But such a view of the relation between God and man would not at the present day be accepted by any philosophy which finds any real place for God in its conception of the universe." It is quite impossible to maintain that God is fully incarnate in Christ and not incarnate at all in anyone else.

Again, Dean Rashdall said: "If we believe that every human soul reveals, reproduces, incarnates God to *some extent*, if we believe that in the great ethical teachers of mankind, the great religious personalities, the founders, the

reformers of religions, the heroes, the prophets, the saints, God is more fully revealed than to other men: if we believe that up to the coming of Christ there had been a gradual, continuous and progressive revelation of God, then it becomes possible to believe that, in one man, the self-revelation of God has been signal, supreme, unique." The central truth of Christianity is that in the life and character, and in the teaching and the Personality of Jesus Christ, the world has received its highest revelation of God.

One of the greatest of our living Bishops has said: "Personally I find, in the view of life which I draw from Christ, so satisfying an understanding of God's purpose and of man's duty and destiny that I am not troubled by doubts as to the Incarnation. I can best express my reverence for Christ when I say that He was *the* Son of God."

Again, then, the Christian may safely say:

"I BELIEVE IN JESUS CHRIST, THE SON OF GOD, OUR LORD."

But if he is also asked to say:

> "I believe that 'the third day He rose again from the dead, He ascended into Heaven and sitteth on the right hand of God the Father',"

will he really believe what he says? Are we really asked to believe that His dead body—physical body—was actually restored to life, was translated as a living man to some other place in the universe, and still lives? that He is still a living man, now nearly 2000 years old, even at this moment sharing a throne ("He sitteth") with His Father? If pressed to explain, the professional theologian will probably shift his ground and say that the actual truth contained in these formularies cannot be expressed in simple language and is therefore enshrined as metaphors. But tens of thousands of parish priests are still telling their flocks that the words are literally true. Metaphors associated with Christian belief are dangerous because of this invariable tendency to harden,

to be interpreted literally, and therefore to result in superstition. Does any single theologian in the world now believe that the living physical body of Jesus still exists as it existed 2000 years ago? What are the probabilities, for and against? Devout Churchmen are still made to say "I believe in the resurrection of the body." Is *that* merely metaphor? Do Churchmen still think they can feed their flocks on empty dreams?

9. The Third Person of the Trinity

During the course of a short address at the close of the confirmation service I attended as a boy, more than half a century ago, the bishop said, "I want to impress upon you all that even the smallest sin against the Holy Ghost will never be forgiven." Much perturbed, I sought the Rector afterwards, and asked him to explain: Why was the Holy Ghost the only one of the three Gods to be picked out for this particular purpose, and how could anybody "sin against" Him and not the other two? The Rector, an excellent parish priest but no scholar, replied that everything the Bishop said must be accepted without question: and he rebuked me for speaking of "three Gods": there was only one; and then he quoted certain credal clauses about "Person" and "Substance". When I left him, I was perfectly convinced, boy as I was, that he had no clear notion of what he was talking about, that he was just repeating words that he had repeated all his life, words which to him had no real meaning at all.—It was in this stupid way that Victorian children were so often taught.

Some sixteen or eighteen years ago, at a certain Church Congress the reader of a paper said: "The historic development of Christian doctrine was so guided and inspired by the heavenly assistance of the Holy Ghost that the Catholic creed and conciliar definitions may be relied on as representing the nearest approach to absolute truth which finite minds are capable of apprehending."

Nobody could question the absolute sincerity of the speaker who obviously believed every word he uttered. But what did he *mean*? To him, precisely who or what was the Holy Ghost? Why did he call the assistance rendered " heavenly " assistance? On what authority had he made the statement? If on the authority of a man, who was his authority? If on the authority of a Church, what was *its* authority? On what grounds did he think that what he himself believed approached " absolute truth "?

Are Christians the monotheists they claim to be? or are they Tri-theists? If the latter, what is the distinction between tritheism and polytheism?

It is necessary to bear in mind that the doctrine of the Trinity is only a *theory*. The theory has been built up on a series of hypotheses, none of which are verifiable.

In popular religion the word " spirit " has come to mean *a person without a body*, which is the child's definition of a ghost. The term Holy *Ghost* is particularly misleading to the uninitiated, and nowadays the Church usually and wisely substitutes the term Holy *Spirit*. The intuition of some of the great religious artists in representing the Holy Spirit by some kind of *light* is readily acceptable. A *personal* representation would be childish.

Why do so many of our leading modern works on theology bestow so little attention to considerations of the Third Person of the Trinity? Is the subject unimportant, or are the expositors afraid? Do they fear to expound such a credal clause " who proceedeth from the Father and the Son "? What sort of mental picture does the average churchgoer form of such words as " dove ", " tongues of fire ", " the rushing mighty wind ", baptismal " regeneration ", " the laying on of hands ", the " inspired Word ", " the Comforter ", " the Holy Ghost "? Canon Raven says, " We pray ' Take not thy Holy Spirit from us '. I have often longed to see into the minds of a congregation and discover what special meaning those words bear for them. To the majority doubtless that clause, like much of our

Prayer-book, is simply a familiar formula recited with a general idea that it is all part of the ritual of a well-spent Sunday."

If we listen to the words of a great divine or of a great orator, if we look at a great picture, if we read a great book, we are necessarily *influenced* by what we hear, or see, or read; we may feel we are learning something more of what is true, or of what is good, or of what is beautiful; we may even be inspired to action (though not necessarily right action). The whole world may be influenced in this way, and we may feel that there is a spirit of some new *truth* (or it may be untruth) abroad. We cannot deny that a great man may inspire a multitude, or that his words and work may create a new influence or *spirit*. This illustration seems to give a possible key to the mystery of the Trinity. Canon Raven's happy analogy is something like this: He imagines an artist painting a picture: the artist's *will* which purposes to create the picture, and the *impulse* which prepares pigments and canvas, is God the Father; the artist's *concept* of the complete picture, his cartoon of the grand design on which the work is modelled is God the Son; the artist's *energy*, the vital and creative *activity* whereby is produced on the material canvas the perfect image which the will has planned and the vision conceived is God the Holy Spirit. "These three, separate in sphere and method, representing *three separate functions* of the artist's *single personality*, are yet one."—Such an illustration of the doctrine of the Trinity is wholly admirable. Gone are the "three Persons" and their thrones. The late Canon Dearmer expressed much the same view: "The really orthodox Christian belief is that there is *one God*, that in the divine nature there are *three ways of existence*, one of which was manifested in the historic Jesus and thus dwelt with *man*, while another is *the source of human inspiration*. In this way we have a rational and acceptable explanation of the credal words "proceedeth from the Father and the Son". The Holy Spirit is the spirit of truth, and this spirit must "proceed" from *God* and from the

teaching of that young working *man* who during his short life was God's "perfect" representative.

Julian Huxley, the biologist and able expositor of modern science, interprets the three Persons of the Trinity and their co-existence in this way: The First Person embodies man's reaction to the stern forces of nature, the Second Person embodies the personal, individual elements in religion, the Third Person embodies the abstract qualities perceived by the human mind—the spirit of truth, of goodness, of justice and mercy, and so on. He thinks that Trinitarianism has at least this advantage—that it cuts the Gordian knot of logic which demands that God shall be either transcendent or immanent by making one aspect of him—the First Person—primarily *transcendent* and another—the Third Person—primarily *immanent*. In this way it avoids the consequences of (1) too much insistence on divine immanence which, if given its head, rushes straight away to pantheism; and (2) over-emphasis upon transcendence which tends to make of God either an arbitrary ruler or a mere watcher. "Thus, by insisting on the simultaneous humanity and divinity of Christ, it lays full emphasis on the true sanctity potential in human nature—the essential divinity to be found in man." *

It is reprehensible in the last degree for any particular Church to claim exclusively as its own the Holy Spirit's sphere of action. It is therefore reprehensible for working clergy to exclude from their altar "sinners" of any particular kind. Did the Master they profess to serve teach them to do *that*? Did *He* keep sinners at a distance? Would *He* have refused them seats at his table?

10. "Mysticism"

This very vague term is "sometimes used as the equivalent of symbolism or allegorism, sometimes for theosophy or occult science; and sometimes it merely suggests the

* See *What dare I think?* pp 233, 235.

mental state of a dreamer, or vague and fantastic opinions about God and the world." In Roman Catholic writers, "mystical phenomena" often mean "supernatural suspensions of physical law". All these things make it clear that the term has a very loose connotation. In fact the term is sufficiently vague for different schools of theological thought to claim it as specifically their own.

Recognized authorities maintain that the thought or feeling which is called mysticism had its origin in that which is the raw material of all religion, namely, a dim consciousness of the beyond. Dr. Inge defines it as "the attempt to realize, in thought and feeling, the immanence of the temporal in the eternal, and of the eternal in the temporal". We seem to have a faculty (conveniently called the "soul") for the discernment of spiritual truth.

Even the philosopher or the researching man of science may suddenly be surprised by an intuition or revelation into a realization of a new truth. Lacordaire wrote, "All at once, as if by chance, the hair stands up, the breath is caught, the skin contracts, and a cold sword pierces to the very soul. It is the sublime which has manifested itself."

Professor Pringle-Pattison says, "Mysticism is a phase of thought or feeling which appears in connexion with the endeavour of the human mind to grasp the Divine essence or the ultimate reality of things." Charles Kingsley wrote: "Mysticism is the belief which is becoming every day stronger with me that all natural objects are types of some spiritual truth or existence." Lasson wrote, "The essence of mysticism is the assertion of an intuition; rationalism cannot conduct us to the essence of things, and we therefore need intellectual vision."

Harnack said, "mysticism is rationalism applied to a sphere above reason." But Dr. Inge writes, "What we can and must transcend if we would make any progress in divine knowledge, is not reason but that shallow rationalism which regards the data on which we can reason as a fixed quantity, known to all, and which bases itself on a formal

logic, utterly unsuited to a spiritual view of things. Language can only furnish us with poor, misleading, and wholly inadequate images of spiritual facts; it supplies us with abstractions and metaphors which do not really represent what we know or believe about God and human personality. . . . When Harnack says that ' Mysticism is nothing else than rationalism applied to a sphere above reason ', he would have done better to say that ' it is reason applied to a sphere above rationalism '."

" St. John's command to ' try every spirit ' condemns all attempts to make emotion or inspiration independent of reason; those who blindly follow the inner light find in it no ' candle of the Lord ', but an *ignis fatuus*; and the great mystics are well aware of this."

" Reason is the Divine Governor of man's life; it is the very voice of God." *"ὁ νοῦς βασιλεύς."*

Beware of self-surrender to the feelings. That way lies atheism, not theism.

Why should we hesitate to say:

I BELIEVE IN GOD'S HOLY SPIRIT?

ADDENDUM

The World Conference on Faith and Order was held in Edinburgh during August, 1937, and lasted a fortnight. It brought together 414 delegates from 122 Christian Communions in 43 different countries. They discussed the causes which kept Christian Communions apart and the things which unite them in Christian fellowship. The Archbishop of York was Chairman.

It is of happy augury that the following affirmation was approved unanimously:

" We are one in faith in Our Lord Jesus Christ, the Incarnate Word of God. We are one in allegiance to Him as

Head of the Church and as King of Kings and Lord of Lords. We are one in acknowledging that His allegiance takes precedence of any other allegiance that may make claims upon us. . . .

"Our unity is of heart and spirit. We are divided in the outward form of our life in Christ because we understand differently His Will for His Church. We believe, however, that a deeper understanding will lead towards a united apprehension of the truth as it is in Jesus. We humbly acknowledge that our divisions are contrary to the Will of Christ and we pray God in His Mercy to shorten the days of our separation and to guide us by His Spirit into fullness of unity. We are thankful that during recent years we have been drawn together, prejudices have been overcome, misunderstandings removed, and real, if limited, progress has been made towards our goal of a common mind.

"In this conference we may gratefully claim that the Spirit of God has made us willing to learn from one another, and has given us a fuller vision of the truth and enriched our spiritual experience. We have lifted up our hearts together in prayer: we have sung the same hymns together: we have read the same Holy Scriptures. We recognize in one another across the barriers of our separation a common Christian outlook and common standard of values. We are therefore assured of a unity deeper than our divisions.

"We are convinced that our unity of spirit and aim must be embodied in a way that will make it manifest to the world, though we do not yet clearly see what outward form it should take. We believe that every sincere attempt to co-operate in the concerns of the Kingdom of God draws the severed Communions together in increased mutual understanding and good will. We call upon our fellow-Christians of all Communions to practise such co-operation, to consider patiently occasions of disunion that they may be overcome, to be ready to learn from those who differ from them, to seek to remove those obstacles to the furtherance of the Gospel in the non-Christian world which arise from our divisions, and

constantly to pray for that unity which we believe to be Our Lord's Will for His Church.

"We desire also to declare to all men everywhere our assurance that Christ is the one hope of unity for the world in face of the distractions and dissensions of this present time. We know that our witness is weakened by our divisions yet we are one in Christ and in the fellowship of His Spirit. We pray that everywhere in a world divided and perplexed men may turn to Jesus Christ Our Lord, who makes us one in spite of our divisions, that He may bind in one those who by many worldly claims are set at variance, and that the world may at last find peace and unity in Him to whom be glory for ever."

Just one Christian Communion stood aloof, viz. the Roman Catholic Communion. That great Church still considers the other Christian churches not as prodigals to be welcomed back, but as wayward children to be punished. Again: the pity of it!

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CHAPTER XIII

The Christian creeds again: Immortality

1. The Christian Churches: Why More than One?

The Papacy—the Church of Rome—reached the zenith of its power in the thirteenth century, and it looked as if its great ambition to become the supreme ruler of the world was likely to be realized. Then, as now, an extremely able bureaucracy surrounded the Pope at Rome, and as in those days all Europe, princes and peasants alike, had for centuries been intellectually asleep, any opposition to the Church was easily crushed. But with the Revival of Learning men began to think, and gradually to revolt both against the futile and servile conclusions of Scholasticism, and against the horrors of the cruel persecutions of the Church. Moreover the lives of many of the clergy had become extremely corrupt, and the sale of " indulgences " (which in practice meant that a man was free to commit " sins " to the top of his bent, provided he would pay the clergy an adequate sum for the licence) a universal scandal. One of the Church's own priests, a learned German, Martin Luther, visiting Rome in 1510 on business connected with his monastic order, was so deeply moved at the irreligion and corruption of the papal court that he went back home and vented his indignation in caustic sermons directed against the Church abuses, which were now familiar to all the world though until now none had dared to attack them. In this way Luther lighted the Reformation fire, which swiftly gathered way. A few years later (in 1529) at the second Diet of Spires the Emperor practically forbade

all further action in the direction of Reformation, and a solemn "protest" was thereupon made by the reformers. It was in this way that "Protestants" were born, and members of the Christian Churches thus became divided into "Catholics" and "Protestants". Broadly speaking, it was Britain and the northern half of Europe that became permanently Protestant; in the countries nearest Rome the reformers were for the most part readily crushed.

But there is no longer any fine line of demarcation between Catholics and Protestants, and nowadays both terms are admittedly very ambiguous. Perhaps the most fundamental difference is that to the Protestant the *Bible* is primarily authoritative, and to the Catholic the *Church* is primarily authoritative. The Catholic Church interprets the Bible in its own way and constructs a body of doctrine which all its members are compelled to accept. It is no part of the duty of a Catholic to think for himself; his thinking is done for him by his Church. But the Protestant goes back to the primitive Christianity of the Founder, and claims the right to read and interpret the Bible for himself.

To avoid confusion with other Catholics, a member of the Church of Rome is best called a *Roman* Catholic.

Occasionally, a member of a Protestant Church will "go over" to Rome; and *vice versa*. A notable convert to Rome in recent years was the late Mr. G. K. Chesterton, of whom his friend Mr. A. G. Gardiner writes,* after referring to his laugh as "a cascade of pure joy", "the material preoccupations of man did not occur to him, and facts had no significance. He wore no harness, learned no lessons, observed no rules. For him, life was an adventure of the spirit in a world that was not governed by 'facts', but compact of romance and mystery and magic. His hostility to science sprang like that of Newman and Wesley from the fact that he saw in the dogmatisms of science the enemy of the dogmatism of the spirit. He took the world in his vast embrace and tried to heave it back into the Middle Ages. . . .

* *English*, Vol. I, No. 3.

But the great tide of events ran against him, and as it rose he retreated more and more into the mists of magic and obscurantism and counted for less and less in the great argument of human destiny."—Surely Rome was the one place where Chesterton, like Newman, could find safe anchorage. We did not love Chesterton for the soundness of his reasoning (he couldn't reason) but because it was so obvious that to him life was a book of gorgeously coloured pictures, the leaves of which he wanted to turn over for us and to help us enjoy the fun in them.

The Roman Church is still the greatest of the Christian Churches, and it could well afford to be less disdainful, less aloof, and less unfriendly to its neighbours. It is so well disciplined that only now and then does any intellectually dissatisfied priest break the leash that holds him, as Martin Luther did 400 years ago. But it happens now and then, and a few years ago a distinguished Belgian Jesuit hit out straight and hard.*—" Popes come and go, but the overgrown bureaucracy that exploits the papacy abides unchanged. Here we have a vast multitude of men for whom the centralization of the Church at Rome means money and position. . . . Will men go on admiring a casuistry of evasion, whose pride it is to whittle away duty to its lowest and meanest terms? . . . Will men listen to you when you teach them implicitly to look down on the natural virtues—truth, courage, honesty, industry, fidelity, humanity—as supernaturally worthless or indifferent, as proceeding merely from man and not from God in man? . . . Will men continue to see the highest fruit of Christianity in a sanctity that is measured by ecstasies, automatisms, stigmata, and all the symptoms of psychic disorder? . . . A still deeper source of this untruthful spirit is the initial error, the *idée-mère* of Medievalism, that gives the authority of divine revelation to a mass of untenable historical and scientific statements. One knows how even a single false premiss will develop into a vast and complex system of falsehood. Bind men's consciences, then, to a

* *Medievalism*, G. Tyrrell.

whole host of such premisses, force them to bring the results of their observation and reasoning into accord with them, compel them to defend such premisses against all gainsayers, and the result must be just what it has been—a profound inward scepticism, an absence of anything that deserves the name of intellectual conviction, a readiness to think black is white when so commanded, and a habit of controversial chicanery and dishonesty. Add to this the decadent and enervating casuistry of the pulpit and confessional which is never weary of insisting on the merely venial character of untruthfulness, and of relegating veracity to the very inferior rank of pagan virtues."*—All this and very much more came out of the fullness of the heart of a highly-trained, highly intelligent and very earnest Roman priest. Needless to say Rome found a means of punishing him. (Father Tyrrell had written a reply to his Cardinal's "Lenten Pastoral", the Pastoral really being a fulmination against "Modernism".)

The Roman Church takes its stand on the assumption that its Faith is a definite "deposit", something closed and final, something to which nothing can be added and from which nothing can be taken away, something admitting of no criticism whatever. A layman who questions it should be damned; a priest who questions it should be damned a thousand times. To throw doubt upon any one of its ancient formularies is impious in the last degree. If newly discovered knowledge clashes with one of the formularies, so much the worse for the new knowledge. How can it be real "knowledge" if it contradicts something laid down by the Church? If the Church has said that transubstantiation is a fact, how can any discovery of science possibly contradict it?

The bitter hatred now exhibited towards the Roman Church in parts of Spain is startling in its intensity and does not seem to be wholly explained by the violent contrast between the great wealth of the Church dignitaries and the extreme poverty of the masses. During the early stages of the Spanish civil war the foul public outrages on the nuns and

* *op cit.*, see pp 165–81

the ribaldry that accompanied the public "executions" of bishops and priests point to a deep-seated and wholly inexplicable devilish hatred.* In France, in Italy, and in Russia, the contempt felt by intellectual men for the Church is too well known to need stressing. The strength of the Church lies in its hold over the ignorant sections of the peoples: the loyalty to Rome of the ignorant peasantry of, for instance, Ireland and French Canada is really pathetic in its fervour. Then, again, old Roman Catholic families commonly remain loyal, and there is a steady drift to Rome of sentimentalists who crave for a religion of a more sensuous kind than that to which they have been accustomed. But the Church of Rome is still by far the most efficiently organized institution in the whole world. Her strength is still enormous, and could she be induced to shake herself free of Scholasticism and to admit her intellectual errors, she might even yet become the dominant world-power she has always dreamt of being.

But she lacks the courage.

Meanwhile we may admire her high standard of sanctity, her discipline, her self-sacrifice.

The "Church of England" is legally established as a Protestant church, and all Anglican clergy at their ordination have subscribed to the Protestant faith, though by no means all of them have scrupulously adhered to the vows they then made. The Prayer Book of Edward VI, with its creeds and its Articles of Religion, by law still remains the criterion of orthodoxy in the Church of England. Protestantism threw over many of the old Roman Catholic conceptions of religion with its "sacrificing" priests, its "saving" formulæ, its mechanical discipline, and such materialist doctrines as transubstantiation. Protestantism is in the very bones of the practical Englishman and Scotsman. But Protestantism has many degrees. Right from the first the more emotional type of worshipper missed the gorgeous ceremonial of the Church he had given up, and women of the more sentimental type

* "5000 priests have been murdered in Spain and 20,000 in Russia" (Bishop of Gloucester at Tewkesbury, July 24, 1937).

have always been attracted by the confessional. At the other end of the scale is the stern Calvinist who is content to say his prayers on the cold flagstones of a little wayside chapel; he needs no priestly intermediary between him and his God. It is perhaps the weakness of Protestantism (it may be its strength) that when doctrinal differences arise, the dissidents are either turned out or else voluntarily withdraw. In this way a multitude of sects has been formed. The dividing differences are often really trifling but they seem deep to those concerned.

Within the Anglican Church itself (Church of England) are three Parties with very different outlooks, formerly referred to as "Low" Church, "High" Church, and "Broad" Church, but now more commonly called Evangelicals (now a very elastic term), Catholics, and Modernists. The first-named include the great majority of the bishops and working clergy, many of them ripe scholars, nearly all of them men of moderate views who are content to do their duty and not to worry over much about doctrinal difficulties; the second-named hate the term Protestant, and are not always loyal to the Church of their adoption; the third-named are, as a body, scholarly, broad-minded, tolerant, and are doing their best to purge church doctrine of its shams and to make it acceptable to men who have learnt to think.

Within each of the first two groups are hues of different depths. A scholarly and friendly Roman Catholic priest said of Protestantism, "I am somewhat chilled by its cold humanism, its naked serenity, its relentless rationality; it certainly feeds the better half of the soul but it starves the other half." This description correctly applies to the extreme types of Evangelical whose rigorous suppression of the emotions is apt to be icy. On the whole, perhaps, Evangelicalism tends to take on colours which are just a little sombre, but it is now tolerant and no longer consigns its opponents to the flames. At one time Evangelicalism fought fiercely for the literal interpretation of the Bible, but it now agrees that the Bible is a record which must be critically scrutinized.

Anglo-Catholics belong to another world altogether. The Tractarians of the last century were amongst the first Anglicans to look wistfully over the fence which divided them from Rome. Newman actually climbed over and stayed there. His friend Pusey remained behind and fought a somewhat lone battle almost till he died, gaining very few adherents and meeting with hostility both from within and without the church. He had few friends and led an austere life. He was the leader of the then small High Church party which was and still is very bitter to its opponents. This party is at present indistinguishable from the Anglican Catholics, who now claim to have on their side nearly one-fifth of the clergy of the Church of England. Though hardly any of them are recognized as scholars of the first rank, they are a most interesting admixture. Not a few of them are in charge of densely populated slum parishes in big towns, devoting themselves to their flocks with an almost fanatical fervour, rarely giving a thought to their own personal comforts or pleasures. All honour to them. Who can blame them for making their Church services attractive to the drab congregations who attend them, even if a somewhat over-elaborate ceremonial is stressed? But there are others. There are priests who are openly contemptuous of Anglican-Protestant forms and traditions, and would, if they could, purge the Church of England of Protestantism altogether. Like Rome, they stress the Mass and the Confessional, desiring to create a devout but subservient type of Christian, emotional rather than intelligent. They are a sacramental priesthood who, if they have not openly adopted the doctrine of transubstantiation, at least go so far as to claim that adoration is due to the reserved sacrament. The only real barriers that now divide them from Rome are Papal Infallibility and Rome's refusal to recognize Anglican Orders. In many ways the Church services of the more extreme priests are wonderfully like those of Rome: the priests are gorgeously arrayed, beautiful symbols for all to gaze upon abound, the music is impressive, the ceremonial is elaborate, and the sweet smell of burning

incense penetrates to every corner of the church; in short, the services tend to give pleasure to the senses with the result that the intelligence is partially numbed. Even the ritual itself is occasionally Roman, and the teaching of Roman sacramental doctrine is not unknown.

Inasmuch as religion is, to emotional people, largely an affair of feeling, such services would be much more readily tolerated by Anglican protestants were the priests less violently vindictive towards those who disagree with them. Though officially Protestant, the priests hate Protestantism. The more intellectual sections of their flock are gradually withdrawing their allegiance.

The Broad or Modernist Churchman is above all things one who has a horror of allowing personal predilections and sentimental antipathies to lead his intelligence astray. He possesses a certain fanaticism of veracity, but he knows well that it is seldom possible to dig indubitable truth from historians' records, and that we have to be content with a scale of degrees—certainty, moral certainty, high probability, low probability, possibility, and so on, down to impossibility. Modernist Churchmen include in their ranks some of the ablest scholars of the Anglican church; for instance, the late Dean Rashdall was one, and the former and present Deans of St. Paul's (Dr. Inge and Dr. Matthews) are others. Modernist Churchmen find it impossible to hold views implying infallibility, and they are much too good historians either to share the belief in Apostolic succession or to accept the hypothesis that the government by bishops dates from the Founder of Christianity. It is a definitely established historical fact that the Christian society as it existed after the death of the Founder was in a wholly unformed condition and that only by very slow degrees did the episcopal system prevail. The hypothesis of an Apostolic succession is not only unhistorical, it is fantastic.

Modern Churchmen have done an enormous amount of work to rid Christianity of many of its superstitions. They are broad-minded and tolerant, and they are out to discover

the truth and show it in a bright light. But the Church of Rome, which maintains that truth has already been discovered, is naturally hostile to the Modernist movement. In their Conference at Cambridge in August, 1921, Modern Churchmen discussed the subject " Christ and the Creeds ", and papers by numerous eminent scholars were read. The papers were all carefully reasoned, moderate in tone, and could not possibly offend anybody who did not desire to conceal the truth. But the then Roman Catholic Bishop of Salford addressed a pastoral letter to his clergy, to be read in the Churches of the Diocese on 2nd October, 1921, and in it referring to the Cambridge Conference said, " such publicly uttered blasphemies must surely be most offensive to Almighty God, and be likely to draw down His divine wrath upon a nation in which they are given currency and even to a large extent approval." Not very friendly language from an alien church to which such friendly asylum has been accorded! Blasphemies! Which is the greater blasphemer, he who searches for the truth, or he who deliberately conceals it? But Modern Churchmen are never troubled by the aspersions of opponents. They are out to bring within the Church the intelligent man who too often remains outside it. They recognize that there are differences of temperament, differences of sensibility, differences of religious practice, but these differences provide no sufficient reason for concealing fundamental truths or for the continuance of mediæval superstitions. Such Broad Churchmen as Kingsley, Arnold, Dean Stanley, and Maurice, stood for everything that is best in the British character—tolerance, rectitude, love of truth, and loyalty to the Christianity of the Founder; and so do their present-day successors. The signs of the times are that the Modernist Movement will gradually attract to its ranks both the Liberals from the Evangelical end of the Church and the scholarly Anglo-Catholics from the other end. The fanatics at both ends will be left high and dry, the hell-sending Calvin-minded parson at one end, the bitterly intolerant sacramental priest at the other.

The English Church is wise enough to allow both types of fanatic to remain within its fold. They are mutually destructive and are a source of perennial interest to the vast majority of men of moderate views. If the one derives spiritual satisfaction from the thought of the burning fiery furnace for his opponents, and the other from adoration of the reserved sacrament, why not let them alone? *But why are they so bitterly intolerant?*

2. The Bible

If the reader is to appreciate the nature of the controversies which gave rise to the Christian creeds, he must make himself acquainted with the history of the Bible (there is an excellent summary in the *Encyclopædia Britannica*), for the Bible is the credal source-book. Unfortunately, however, most of us have been trained to regard the Bible not as a book whose parts have varying degrees of value but as a talisman sent down to us from heaven, with all its parts equally authoritative and equally significant. Yet there was a time when the Jews drew very far-reaching distinctions between the various books of the Old Testament; and the Christians between the various books of the New. To treat the Bible as the Mahommedans treat the Koran, as wholly fine gold instead of a gold alloy, is nowadays known by scholars to be absurd.

The very expression "Canonical Books" (the authorized standard books of the Bible) points back to a time when all parts of the Bible did not stand on the same footing. There was a time when the Bible contained books which are now omitted. There was a time when some of the present books of the Bible were not considered genuine; St. Athanasius rejected the book of Esther, the Greek Christianity of the East rejected the Apocalypse, and the Latin Christianity of the West rejected the Epistle to the Hebrews. The main reason for these rejections and for numerous other differences

of opinion was the development of an increasingly critical sense of relative values. After a long time, discussion died out, not because a perfect canon of scripture had been finally agreed upon, but because mediæval ignorance had deepened, and there was no longer enough knowledge or interest in the world to keep the discussion alive.

How as children we all loved to read parts of the book of Daniel, one of the inferior and later books full of the spirit of the time, grandiose but turbid and phantasmagoric, containing passages which, when Christ came, constituted the basis of the popular religious hope and belief of the Jews. How disappointed the Jews became!

For centuries theologians assured the people that the Bible was perfect and infallible. It was inevitable therefore that the ordinary uneducated person should misunderstand it, should treat it as all gold, should read it without any sort of discrimination. Without any experience of the ways in which men have thought, spoken, and written, utterly unable to gauge the intentions of the writers of the Bible, how could such a person read the Bible intelligently? How could he be expected to read between the lines and discriminate between the kernel and the husk? As Matthew Arnold said: "Our mechanical and materializing theology, with its insane licence of affirmation about God, and about a future state, is really the result of poverty and inanition of our minds. It is because we cannot trace God in history that we stay the craving of our minds with a fancy account of him, made up by putting scattered expressions of the Bible together and taking them literally."

The interpretation of the New Testament taxes the resources of our greatest scholars. How can we tell whether the stories recorded, often gathered from different sources many years after the actual happenings, are truly in accordance with the original facts? How can we be sure that the writers gave truly uncoloured accounts of the stories they had heard, or whether they coloured them, for or against, with their own prejudices? When they followed the common

practice of the time and made free use of metaphor, how are we to understand exactly what they *meant*? Many theologians have built up systems on the words of St. Paul, and St. Paul was certainly a deep thinker who lived in the full stress of the religious awakening to which he furnished ways of thought, and he had lived in places where the light of Greek culture was bright; *but* his mental training had been narrowed by rabbinic subtleties and logomachies, and it is idle to think that his mind had not been permanently warped by them, at least in some measure. But it is the Fourth Evangelist who is perhaps the greatest source of anxiety to readers of the New Testament. Of all the writers in the New Testament, St. John (we may conveniently assume that he was the author of the Gospel) was by far the most indifferent to truth of fact. He does not hesitate (even such profound scholars as Westcott and Hort agree about this) to put into the mouth of his Master words which are really the fruit of Christian religious experience, and which bear the hall-mark of his own very distinctive style. And yet at the same time he insists on the supreme value of truth again and again. How can such a writer neglect truth in his narrative and give an account of the life of his master which is from beginning to end tinged with notions which prevent him from seeing events in a neutral light? St. John was, of course, a great mystic, living in the world of spirit rather than in the world of sense. He was much the same type of man as Plato and Plotinus, and like them he often leaves us doubtful of his meaning.

Consider the very first sentence of his Gospel:

In the beginning was the Word.

If in the usual way we try to discover the meaning of the sentence by subjecting it to minute philosophic analysis, we try to determine the significance first of the noun *beginning*, then of the phrase *the beginning*, then of the prepositional phrase *in the beginning*. Does "beginning" mean the beginning of the universe, or the beginning of evolution, or the

beginning of infinite time, or what? Then, why *the* beginning? Was there never any other beginning? Does *in* the beginning mean *at* the beginning, or *within* the beginning? And so we go on with the remaining part of the sentence, and lastly try to fathom the intended meaning of the whole.

But the English sentence is only a translation of the Greek, and it is so vague as to convey to the mind practically no meaning at all. We must go back to the Greek itself, and submit *that* to minute analysis. It so happens that in this case the two sentences form an almost word-to-word parallel:

ἐν ἀρχῇ ἦν ὁ λόγος

What does this mean? Only a first-rate Greek scholar can tell us, and even he will be uncertain about the significance of the term *logos*. Greek scholars simply do not agree as to the Evangelist's intended meaning.

Literally, the Greek word *logos* means that which is said or spoken, a word, saying, speech; also the power of the mind manifested in speech, analogy, the reason, &c. In theology it usually signifies the Divine word; the transcendent Divine Reason as expressed in a distinct personality; the Second Person in the Trinity both before and after the Incarnation. But the term was in use hundreds of years before Christ's time. It was used by **Plato** for *reason* as signifying an emanation from the Supreme Being. **Philo**, the scholarly Alexandrian Jew, using ideas and language partly Platonic and partly scriptural, seems to have given the term logos primarily the significance of Divine Wisdom. Thus even in pre-Christian days the word was essentially a mystical word, and when therefore the mystical fourth Evangelist seized upon it and used it with very varying connotation, any precision of meaning is hardly to be expected. The writer of the fourth gospel may really have been the very zealous Jew-Christian, the son of the Galilean fisherman Zebedee, but he was certainly not a trained philosopher: and, whoever he may have been, his careless regard of facts certainly unfitted him to make use of philosophical terms. The real significance of the term logos

has always been the despair of scholars, and yet theologians have built up a doctrine of the Logos and have made it the very foundation of important parts of the Christian faith.

The Bible teems with uncertainties of this kind. " The infallible Book has gone the way of the infallible Church."

3. The Creeds

Ever since the very early days of the Church, definitely formulated confessions of faith have played an important part in both the liturgy and theology of all denominations. At first they were simple confessional formulæ used at baptisms, but since the Council of Nicæa (325) they have also served for dogmatic decisions of ecclesiastical councils. Of the three well-known creeds the *Apostles'* Creed is the simplest but its history is a little uncertain. More important is the *Nicene* Creed.—Throughout the second and third centuries there had been keen controversies as to the nature of Christ, and early in the fourth, a distinguished Alexandrian presbyter named **Arius** expressed the view that Christ was neither con-substantial nor co-eternal with the Father; he was anxious to maintain the monotheistic position—that there was only *one* God and not two, and he therefore described the Son as a created Being, though immeasurably surpassing all others. Many of the bishops, including **Eusebius**, supported Arius, but others opposed him, and to settle the dispute the first œcumenical council was called at Nicæa in 325. The older or orthodox view was championed by an Alexandrian Deacon named **Athanasius** who insisted that the Son was " of the same substance " (*ὁμο-ούσιος*) with the Father, and round this word the battle raged; the Arians, led by Eusebius, wished to describe Christ not of the *same* substance but of *similar* substance (*ὁμοι-ούσιος*) as the Father. On a vote being taken the Athanasians proved to be in a majority over the Arians; Arius was denounced as a " heretic " and afterwards banished, and the " orthodox " creed was promulgated. At

a later council some additions were made. The main point of interest here is that at the Nicæan council, two rival hypotheses were considered, neither one of which could by any conceivable means be put to any sort of final test. A conclusion could only be a matter of purely personal opinion. And yet we are gravely told that the Athanasians were guided by God's Holy Spirit, and that the Arians were prompted by the Devil to convert a vowel into a diphthong! (It is unlikely that the *Athanasian* Creed had any sort of connexion with Athanasius himself; it is of a much later date.)

It is essential to bear in mind that the statements of the creeds are merely attempts, made many centuries ago, to give expression to the early Faith of the Gospel. For centuries men disagreed violently, but those were centuries when civilization was still a child, when science was scarcely born, when men had not learnt how to reason from facts or to discriminate between fact and fancy. During that time the Bishops, with a good deal of help from the Emperors themselves, did their best to hammer out acceptable creeds, and they recognized that creeds must *develop*, must *evolve*: and it is impossible that the creeds, as thus so far worked out, should escape the human errors which mingle with all things, even the New Testament. Then darkness settled down over Europe and the hammering out came to a full stop. When nearly 1000 years later, men woke up again, the Church, quite arbitrarily, accepted the old creeds as something sacrosanct and never to be touched again; not something still to evolve and develop in the light of new knowledge pouring in from all sides, but something supernaturally revealed, final formulas, the *ipsissima verba* of the Holy Spirit.

The knowledge of the early Christians was a child's knowledge; their intellectual horizon was only that of a tiny pond and that pond was enshrouded in mist. Mediævalism laboured long and earnestly to build round that little pond a fence unbreakable and unscalable. Then came along the Renaissance which converted the pond into so vast a lake that the intellectual horizon around it seemed to be

unbounded, and bright light flowed in from all sides. But how the Church resented it!

Since the Renaissance, an enormous change has gradually come over our ways of regarding the world and of interpreting experience, and the greatest of the writers of the ancient world necessarily seem to us like children. Our notions of scientific and historic truth are entirely different from theirs. But how the Churches resent it!

It is the hard shell which encases the creeds that is their real danger during any period of rapid change and development, and that is the case now. Will the Churches restate their formulas, interpret them in the light of the vast stores of knowledge discovered during the last 1500 years, and express them in language which unlettered people will understand? Or will they still expect their congregations to recite the creeds mechanically, as if reciting the multiplication table? And will they still dare to maintain that the creeds are infallible? Professor **Percy Gardiner** has well said that the acceptance of an infallible authority implies that one becomes a religious parasite, and that all parasites tend rapidly to degenerate; but that the modest and courageous respect for an authority recognized as imperfect is an attitude not only to which we are driven every day but by which alone we can lead a worthy life.

Hooker, the sixteenth-century Cambridge (and later American) divine is often quoted as an authority on various phases of Christianity, but his real greatness lies in the fact that he provides us with a criterion of criticism for Church dogma: "Church dogma is not written in black and white in the Bible; it has to be collected from it." Dogmas "are in scripture nowhere to be found by express literal mention, only deduced out of it." And then he assigns the one right criterion for determining whether a dogma is *justly* deduced: the criterion of *reason*, much reviled reason. The main issue for Hooker was to fix the *method* by which a creed may finally be judged. The one weapon which the contending Arians and Athanasians used at Nicæa was *reason*, and to

suggest that God's Holy Spirit was siding with the latter and the Devil with the former is, as we have suggested before, something like coarse blasphemy.

To confuse dogma with religious truth is the mark of naïveté indeed. A dogma is a *reasoned-out deduction* and therefore may or may not be true. Who these days would admit as *true* all the dogmas of the Athanasian creed? They are all deductions from the Bible and some of them palpably false deductions made by some blundering and unskilful man or men utterly unfitted to deal with such a complex literary and philosophical problem. And yet there are still those who maintain that the Athanasian creed correctly enumerates *the facts of the Christian faith*!

The *pre-Christian* religions had no creed: is a *Christian* creed necessary? Men certainly tend to think about things differently. *Quot homines, tot sententiae.* Could we devise a minimum statement of Christian belief that would be acceptable to all? "Proofs" of even such a minimum statement would be impossible, and, after all, what might be proof to one man might be doubt to another; our proofs are only variations of our convictions. It would in any case probably help if we did as the Fathers at Nicæa did, and used the formula *we believe* instead of *I believe*, thus voicing the universal belief of the Church instead of our own private views. The present Head * of one of the Oxford Colleges, and previously Headmaster of two of our most famous Public Schools, a man with a wide knowledge of highly intelligent young people, in discussing the question, "Is a creed necessary or desirable?" said (at Cambridge, 1921), "Words must limit, and we know too well that with the process of time they become bands which cripple growth. They may express our highest experience now:

> "Yet all experience is an arch wherethro'
> Gleams that untravelled world, whose margin fades
> For ever and for ever.

* Dr Cyril Norwood, President of St John's.

Let us not by any creed set bounds to God's horizon. . . . It is unwise to attempt more than a statement of the absolute essentials. On that foundation we can build each our own building. I put it to you that the essential things are no more than these:

> "I believe in God the Father, and
> in Jesus Christ His only Son, and in
> His Holy Spirit.

You may say that this is not enough. I can only answer that it was enough for St. Paul, and it was enough for St. John; and, above all, it was enough for our Lord and Master, Jesus Christ."—I would submit that some such word as *unique* is preferable to *only*. Otherwise, how wholly admirable is the President's suggestion.

The ordinary Christian's most robust belief is belief in the Trinity. That cardinal article of faith is derived directly from the Bible. But if we have doubts about the Church's *reasoned-out deductions* from biblical statements which are only too often obscure, why should we not be allowed to maintain them? Why should our clear-cut bed-rock faith be given a ragged edge of credulity? Why do the Churches try to suppress our individuality? *Why should we all think exactly alike?* On what grounds should ancient philosophy and science be allowed to colour our creeds, and modern philosophy and science be rigorously excluded from them?

It was a former Archbishop of Canterbury, the father of the present Archbishop of York, who said, "Our theology has been cast in a scholastic mould. We are in need of, and are being gradually forced into, a theology based on psychology. The transition, I fear, will not be without much pain; but nothing can prevent it." Truly the Churches will have to find out what sort of Christian religion modern intelligent men need. It is of little avail to use ancient prescriptions for imperfectly diagnosed modern mental and moral maladies, any more than for ailments of a purely physical character.

We may complete this section with a quotation from the *Report of the First Anglo-Catholic Congress*, 1920;

> " The Catholic creeds and conciliar definitions may be relied upon as representing the nearest approach to absolute truth, which finite minds are capable of apprehending." (p. 64).

Ought we to feel indignant, or ought we to feel sad? Does the writer of those words honestly think he can persuade intelligent men of the present day to go back a thousand years and bathe in the turbid waters of Mediævalism? *To what extent do his words help clear away the deepening doubts of educated modern Christians?*

4. Immortality

Now we come to the main subject of the chapter, and we may begin by quoting once more from that same Report of 1920:

> " If we take what was actually taught by it (the Church) during the undivided period, and still is taught in common by the two greatest of the Christian bodies—the Roman Catholic and the Eastern Orthodox—as authoritative, we shall find that we have a perfectly definite and coherent body of information about God, man, our destiny in the next world, and the way of salvation in this." (p. 67.)

The writer has safeguarded himself by the conditional clause, but it is evident that we are to accept as " authoritative ", " a perfectly *definite and coherent body of information about our destiny in the next world.*"

Information! *information*!!

(i) Some Ancient Notions of a Future Life

It is interesting to compare the opinions, held by different classes of people, about a future life, e.g. care-free people

who never give the subject a thought; serious people engrossed in their daily labours; devout people devoted to their church; ordinary well-educated people; country parsons who, although perhaps not intellectually gifted men, are excellent shepherds of the flocks assigned to them; highly-trained theologians; eminent men of science; philosophers. Necessarily the opinions will differ widely, some being wholly worthless, some being the result of much thought, but all of them *opinions*. Or, suppose we study archæology, ancient customs and ritual, ancient epitaphs, and ancient literature, and try to track down to their sources the views commonly held: do such sources provide us with any *knowledge*?

A particularly interesting lecture on *Some Greek and Roman Notions of a Future Life* was given by that well-known Oxford scholar, Mr. Cyril Bailey, to the Leeds Branch of the Classical Association in January, 1915, and every reader of this chapter should try to obtain a copy and ponder over its contents. Mr. Bailey shows that the Greeks held different views at different times. The spirit of the dead Agamemnon, for instance, was supposed to be in his tomb or in the earth around or beneath it (Aeschylus, *Choephoroe*). But if we pass to Homer we find a very different conception of the after-life; at the moment of death the spirit leaves the body and flies "twittering" to "the House of Hades", to lead with the other departed spirits a colourless shadowy existence, feeble and inert, without mind or will or power (*Od.*, XXIV, &c.). A third idea may be gathered from J. W. Mackail's *Selections from the Greek Anthology*, Epitaphs, LXII—a tacit negation of any belief in survival. The "bitter lines" of Callimachus may be given in Dr. Mackail's translation:

> "Does Charidas in truth sleep beneath thee?—If thou meanest the son of Arimmas of Cyrene, beneath me.
> "Oh Charidas, what of the underworld?—Great darkness.
> "And what of the resurrection?—A lie.
> "And Pluto?—A fable; we perish utterly."

The Romans seem mainly to have followed the lead given them by Virgil: we may turn to the Sixth book of the *Æneid.*—Æneas wished to consult his father who had died, and he obtained permission to visit him in the world below; his experiences on that journey remain for all time the epitome of the ancient vision of the after-world.—The greater part of the Sixth book is devoted to a description of those grim experiences during his fearsome journey across the Styx and onwards. Even Æneas, bold as he was, was appalled at the sight of, and the sounds from, the dreadful prison-house to the left of his road, a prison-house surrounded by triple battlemented walls, a rushing river and waves of torrent fire. Æneas asks his guide to explain:

> "Gnosius hæc Rhadamanthus habet durissima regna,
> Castigatque auditque dolos, subigitque fateri,
> Quæ quis apud superos, furto lætatus inani,
> Distulit in seram commissa piacula mortem.
> Continuo sontes ultrix accincta flagello
> Tisiphone quatit insultans, torvosque sinistra
> Intentans angues, vocat agmina sæva sororum.
> Tum demum, horrisono stridentes cardine, sacræ
> Panduntur portæ. Cernis, custodia qualis
> Vestibulo sedeat? facies quæ limina servet?
> Quinquaginta atris immanis hiatibus, Hydra
> Sævior intus habet sedem: tum Tartarus ipse
> Bis patet in præceps tantum, tenditque sub umbras,
> Quantus ad ætherium cæli suspectus Olympum.
> Hic genus antiquum Terræ, Titania pubes,
> Fulmine dejecti fundo volvuntur in imo."
>
> (566–581).

Æneas wisely resists the temptation to make a personal investigation of this place of horrors, pursues his way, and eventually discovers his father, Anchises, in Elysium, a kind of permanent holiday resort with many attractions. Virgil certainly had a lively imagination (he was scarcely outshone

in after years by Dante and Milton), and it is always interesting to listen to the remarks of intelligent schoolboys when they are reading this Sixth book of the *Æneid.* The monsters at the gates of hell are always an unfailing source of flippant interest.

Popular sentiment concerning the survival of the dead is very largely derived from old tombs and the monuments and epitaphs associated with them. Popular notions concerning the existence of hell and its horrors originated in large measure from the early Church. The early Fathers did not, it is true, treat the Sixth book of the *Æneid* as a gospel, but they did borrow many of the poet's fantasies, amplifying and intensifying the Virgilian horrors in order to provide an adequate punishment for all pagans and heretics.

(ii) Immortality the Greatest Human Obsession

"Some of the grandest Psalms fulfil their music without the echo of one of the far-off bells of heaven," and yet most people seem to pitch their religious life in terms which include a hope of the future. Upon immortality they place an exaggerated emphasis. Tennyson's emphasis was almost violent: "his belief in personal immortality was passionate—almost the strongest passion he had".* He is recorded as saying in conversation, "if immortality be not true, then no God but a mocking fiend created us. . . . I'd sink my head to-night in a chloroformed handkerchief and have done with it all." There can be no doubt that there are a great many men and women for whom a life hereafter is an almost perpetual craving, and the universal interest in the subject may in some measure be gauged from the fact that in Alger's *Critical History of the Doctrine of a Future Life* there is a bibliography of more than five thousand books in which it is treated. The idea that the self cannot be immortal does, however, often occur to us, and even if reflection drives it away it besets us again in unreflective moments. But we human beings seem

* *Nineteenth Century*, January, 1893.

so utterly insignificant when compared with the stupendous universe in which we find ourselves; and it is always hard, and sometimes it seems impossible, to believe that we are the only permanent elements in a universe in which even the planets and the stars have little more than a momentary existence.

(iii) Would the Discovery of Apparitions settle the Matter?

Some of the churches have always had a keen desire to support their creeds by means of miraculous happenings. They are not content with the greatest miracle of all—the existence of the Deity and His evolution of the universe: they want miracles of a smaller kind to happen, and sometimes they go so far as to ask the Deity to suspend His own natural laws and reveal Himself in some special way, for instance they may pray for rain, or for fair weather. But they almost fiercely resent any kind of *test* being applied to miracles. A leading theologian once got himself into serious trouble by proposing that the efficacy of prayer might be tested by offering up special prayers for the patients in one ward of a hospital and not for the patients in the others; and when from time to time it has been quite seriously suggested that transubstantiation might be tested scientifically by means of chemical analysis, a veritable howl of execration went up from those who were specially interested in the doctrine. The impiousness of the suggestion!—Why were the objectors afraid? They probably remembered only too well that the doctrine of transubstantiation was laid down at a time when nothing whatever was known of the chemistry of matter; and the ancient connotation of that unfortunate old term "substance" has long been regarded as meaningless.

All the world knows that from time immemorial there have been reports of the appearances of "ghosts", the apparitions of people who have died; but it is only within the last half century that any serious scientific attempt has been made to investigate such phenomena. So strong was

the prejudice against investigation that would-be investigators ran some risk of social ostracism. However, the Society of Psychical Research was formed in 1882, and men and women of great eminence in the world of science and letters have been members. Amongst its Presidents have been the late **Professor Henry Sidgwick,** and the late **Earl Balfour,** such physicists and chemists as the late **Sir William Barrett, Sir William Crookes, Sir Oliver Lodge,** and such philosophers as **Henri Bergson** and **William James.** The main object of the Society was to investigate, and it is safe to say that most of the investigators were scrupulously impartial. A large number of the investigations which were conducted proved conclusively that the claimants to super-normal powers were rank impostors, but there was a residuum of evidence which seemed to point to phenomena quite outside the scope of known scientific law. Many of the leading investigators suspended judgment, a few scoffed and said that the claimants had outwitted them; others, including Lodge, Crookes, and Barrett, were driven by the evidence to believe that there were psychic phenomena which were clearly extra-physical. Certainly in recent years the seances have been held under the most stringent experimental conditions.

The subject is much too big to deal with in the course of a few paragraphs, but the reader may consult an "international symposium" on psychic problems generally, published under the title of *The Case for and against Psychical Belief*, by the Clark University (Mass., U.S.A.). Contributions from fourteen writers deal with such questions as death, survival, and the communication of the dead with the living, and they range from the ardent convictions of **Sir Oliver Lodge** and **Sir Arthur Conan Doyle** to the strong antagonism of **Professor Jastrow** and **Harry Houdini. Dr. F. C. S. Schiller** writes on "The Logical Aspects of Psychical Research", and adopts the rôle of an impartial judge.

Those who know anything of the work of Sir Oliver Lodge will receive his views with great respect, but Conan Doyle though in his early days a medical man became a

writer of fiction with powers of imagination beyond the ordinary **Mr. Bligh Bond's** "proof" from buried antiquities at Glastonbury is certainly readable. Professor Joseph Jastrow's views may be gauged from his statement, "*every one* of the photographs offered by Sir Conan Doyle is spurious, and has been produced by fraudulent means," and those photographs were the key to the casket that held all poor Doyle's contributions. Houdini was a world-famous magician, and his ruthless exposure of psychic trickery is enough to shake to their foundations all the spiritistic churches in the world.

Despite a certain amount of evidence that seems to be inexplicable, I remain quite sceptical about the claim that the activities of the dead have been demonstrated and that intercommunication has been shown to be a fact. When mediums will allow investigators to bottle up a supply of "ectoplasm" for purposes of future physical examination and chemical analysis, and not assert that it is a material which "because of its semi-psychic nature" disappears on exposure to light, we may begin to believe in "materialization". For the present, at all events, psycho-physical phenomena cannot be accepted as proven. Telepathy, and conceivably clairvoyance seem, however, to belong to a different category. Serious investigators do feel that a mind may in some way act upon another mind, though how there can be a transfer from brain to brain, presumably by nervous waves of some kind, is at present utterly inexplicable.* (If silent prayer has any significance at all, there must be communication at least between the human and the Divine mind). But table-turning, bell-ringing, tambourine playing, childish slate-writing, empty messages from the dead—no. Exposures of these and other frauds have been far too numerous to admit of the inference that now and then the phenomena have genuinely been produced by the activities of the

* In this connexion the reader may be interested in Mr. W. Grey Walker's article, *The Electro-Encephalogram in Cases of Cerebral Tumour*. (Proc. R. S. Med, vol xxx, section on Neurology, March, 1937.

dead. It may with fair safety be assumed that the "ghosts" of the dead which have been "seen" at seances—always arranged in the dark or at most in red light because of the effect of ordinary light on "psychic manifestations"—have been produced by good healthy live mediums, mostly women, generally with the help of one or more confederates. If my own scepticism were shaken at all, it would be because of my respect for Sir Oliver Lodge, whose work in physics has been familiar to me for nearly half a century. Of his absolute honesty I have no doubt at all, and his powers of observation and reasoning are quite outstanding.

That the subject of psychics has not received the official attention of a great public body like the Royal Society has always been a source of puzzlement. It is part of the Society's business to encourage research, and in view of the clamant demands of many reputable people that research into a (supposed) entirely new class of phenomena should be made, it might have been expected that the Society would have taken action. Those of their number who, like Crookes and Lodge, felt interested had to work without official encouragement; in fact there was one Fellow of the Society who expressed the view that Lodge ought to be expelled for his association with psychical research workers. Science is rarely so intolerant.

At first sight it is also puzzling why the Churches have always frowned upon psychic investigations, for it might be supposed that if it could be proved that the dead were still interested in mundane affairs it would strengthen the credal belief in the resurrection of the dead. But the real opposition of the official Church is to a possible *demonstration* of the existence of departed spirits. Clearly, if ghost stories were true the facts to which they testify would, *ipso facto*, cease to be supernatural. The necessity for a belief in the miraculous would then be weakened. "Faith" can be robust, the theologians urge, only in the absence of knowledge that can be put to a test.

The question still remains to be answered, if it could be

proved that apparitions of those who have "died" really do appear, *would that prove the resurrection of the dead?* The answer is emphatically in the negative. Even the most optimistic investigators do not claim that a psychic reappearance ever manifests itself for more than a short period after the death of the body. I believe it is still claimed that communications may still be opened with a former enthusiastic spiritist, W. T. Stead, who died in 1912, but such a claim is exceptional. Why mediums do not occasionally call up, say, Torquemada, or Nero, or the Queen of Sheba, or Noah, they do not explain. It is only fair to the spiritists to say that they do not claim that psychic appearances are evidence of the "resurrection of the *body*", but only the survival of the human personality in its familiar earthly appearance. But even if such reappearances be granted, there would be no evidence whatever of "immortality".

(iv) The Future Life: Firm Belief? or only Expectation?

It is recorded in the Acts that Stephen was stoned to death by a hostile crowd whom his preaching had worked up into a frenzy, and we are told that he said, "Behold, I see the heavens opened, and the Son of Man standing on the right hand of God." Professor Gardiner says, "Comparing this account with other passages in Luke (the writer of the Acts), we may be sure that to the Evangelist this was no mere spiritual vision but the beholding of material realities. St. Luke thought that risen bodies could not only take a seat in heaven, but also feel hunger, eat food, and be touched by the hand, and were made of flesh and bones."* And Luke was a medical man! It is Biblical passages of this kind that tend to strengthen the anthropomorphic ideas of simple minds. There are still simple-minded folk who believe that their *dead bodies* will be restored to life and will "rise again", that there will be a cataclysmic return of the "Son of Man",

* See Luke, xxiv, 31.

and that the quick and the dead will be formally "judged"; and they adhere to the grim and terrible doctrine of an eternity of either unalloyed happiness or of horrible torture. It is doubtful wisdom to try to chill a faith so firmly though so pathetically held; it could only lead to unhappiness. But to try to convert to such a doctrine the intelligent and inquiring youth of the present day is to cut at the very roots of organized religion. It is a sure way of converting youth into scoffers.

Our ancestors believed the universe to be a small place, the earth being at the centre and occupying God's whole attention. They believed man to have existed for only about 4000 years, and that, so far as man's earthly career was concerned, it would all come to an end on the great Day of Judgment which might be expected at any time. Many eschatological details had, it was believed, been revealed to the Church, and Paradise would be an eminently comfortable place for a select few. The number of the quick and the dead to be brought up for judgment would be large, it was true, but not so overwhelmingly large that both heaven and the nether regions could not easily be visualized, though by far the greater number would be consigned to the latter on being refused admission to the former.

I once asked a clergyman—a very worthy man—who had been preaching a sermon on the subject of the Last Day, if he had ever tried to visualize the Paradise to which he had been referring. He replied he was convinced that the great rulers of the world and of the Church would be there, "in view of the noble work they had done for God"; and right in the foreground he placed all the Christian bishops. Asked if bishops who had been guilty of heresy would be included, the Arian Eusebius, for instance, he became most unhappy. The interesting point was that he was imbued with the notion that there must be an aristocracy in heaven as there had always been on earth. Mere personal virtues would count for little.

But if with our vastly increased knowledge we now

attempt some sort of visualization of heaven and of hell, the imagination is staggered by the vast number of human beings to be brought within the picture. It is pretty safe to say that our human ancestors date back a million years. The population of the world at the present time is about 2000 million, over one-fifth of which are Chinese. If we allow an average length of life of 25 years (probably too high an estimate, in view of the great mortality, especially of children, in past ages), and take into account the small populations of very early times, possibly something like a billion human beings have been born into the world up to the present; and if we allow another thousand million years (certainly an under-estimate) before the earth becomes uninhabitable, the number of human beings probably yet to be born is almost beyond comprehension. Nevertheless *all* of them, we are told, will come up for judgment, and a few be sent to the right, and the majority to the left. Those to the left will include all pagans, that is all pre-Christians and all non-Christians, in addition to all Church-offending Christians. Paradise must be kept exclusive. Our half-brutish ancestors did at least one thing—they struggled to live, they did their best to guard themselves from death, and in their way they hoped for immortality. Are we to deny *them* future happiness and consign them to eternal torment? One out of every five of that stupendous crowd before the Judgment Seat (a mere million will be as a drop in the ocean) will be Chinese; are *they* all to be consigned to perdition? Are all human beings outside the tiny circle of subservient Christians, no matter how virtuous or how heroic their lives, to be denied seats at heaven's banquet? The wickedness of such ecclesiastical exclusiveness—what language is strong enough to condemn it? How intelligent youth scoffs at such uncharitable views!*

Dr. Schiller says, "Though the traditions of the Christian Church apparently support the doctrine of a future life, its assurances are anything but explicit, and we must be easy to satisfy if we are content to accept them as conclusive. For

* See also Chap. XI, § 10.

it would be difficult to devise any eschatology more obscure, fragmentary and ambiguous than that of the traditional religion, or one which so ingeniously combines the defects of raising insoluble difficulties, and of yet leaving us without answer upon the most critical points."*

Whether or not we believe in the resurrection of the physical body of Christ, we certainly cannot infer that there will be a resurrection of our own physical bodies, for whatever else we do when we die we leave our bodies behind, in our graves or elsewhere, for disintegration and destruction.

Apart from any dogma of the Church, belief in a future life is commonly maintained on one of two grounds. The first of these is its *moral necessity*, for if there is to be any reason or justice in the order of things, there can be no reward for good or punishment for evil if there is no future life. But "what if things be inherently irrational and perverse? That all should come right in the end is an assumption we can by no means make as a matter of course, and, until it is established, the argument from moral necessity is simply arguing in a circle."† The second ground for the assertion of a future life is a *postulate of feeling*. This argument seems to require something like universality of this feeling, but such universality certainly cannot be maintained. For instance, the history of Hinduism shows that in certain circumstances the prospect of the continuation of life may actually come to be pretty universally regarded with horror and detestation, and that the loss of personal existence by absorption into the Absolute may become the highest object of desire. And can it be said that Western peoples are wholly free from the same desire? Who would not prefer annihilation to the torments of eternal damnation?‡

The Apostles' Creed, as it appears in the Morning and Evening Services and in the Catechism in the Prayer Book, contains the clause, "I believe in the resurrection of the body". But the word "body" should read "flesh", which

* *Riddles of the Sphinx*, p. 371 † *op. cit.*, p. 374.
‡ *op. cit.*, cf. p. 375.

is the correct translation of the Latin and appears accurately in each of the three Baptismal offices and in the Order for the Visitation of the Sick. The belief in the literal resurrection of the physical body was dominant in the Church until very recent times. But the alternative expression " resurrection of the dead " (Ἀνάστασις νεκρῶν for σαρκὸς ἀνάστασις), with its less necessary materialistic interpretation, was substituted in the creeds of Eastern Christendom, and the clause is similarly expressed in our own Nicene Creed. But the interesting point in the Nicene clause is the substitution, for belief, of the idea of *expectation.* In the Apostles' creed we have:

" I *believe in* the resurrection of the body,"

and in the Nicene creed:

" I *look for* the resurrection of the dead."

The term " look for " implies *expectation* and is a much more softened and generalized term than the rather harshly committal term " believe ". Who any longer expects the rising of human bodies from land and sea, and their complete rehabilitation from museums and from battlefields? The great mass of Christians do expect life beyond the grave, but life beyond the grave admits of many interpretations.

(v) The Facts of " Life " and the Phenomena of " Death "

All living organisms, whether plants or animals, whether high in the scale or low in the scale, consist of an assemblage of living cells which, though differing largely in function, work together as if harmoniously organized into a unity which provides for growth, maintenance and reproduction. Many of the complex organic substances occurring in living organisms can now be synthesized from inorganic substances in the laboratory, but these substances when produced are invariably lacking in what we call " life ". What " life " is,

we do not know, but its fundamental nature is being sought for in an investigation of simple living cells and unicellular organisms, which are always active centres of chemical action. Living tissue from complex organisms may be kept alive outside the organism if provided with suitable nourishment and if waste products are removed. The constituent cells can actually be seen dividing and multiplying, exactly as in the case of such independent unicellular organisms as the amoeba. Chemists can make already living tissue grow, *but they cannot make living tissue.**

Such evidence as we have suggests that the earliest living units originated from non-living materials in the primæval oceans, but so far the chemist has never been able to initiate such a process, and therefore he is still uncertain of the actual nature of life.

By our ancestors, " life " was identified with breathing. Hence the term " spirit " (Lat. *spiritus* = breath). Present-day medical men usually identify it with the heart-beat. But, as Professor Haldane reminds us, the heart is merely a blood-pump, and the lungs a blood-aerator. Biologists can already keep the rest of an animal alive for some hours with an artificial heart and lungs, and it is a matter of interesting speculation when it will be possible to remove from the human body any diseased part and substitute a properly working substitute. If we look down the ages still to come, we can contemplate the possibility of the whole of a *natural* man being gradually replaced by an *artificial* man! Would that man be a living being? Would he be a man, i.e. a man still in the sense of having a *personality*: would he be able to think, to remember, to plan, to love, to hate? Would he be the *same* man?

To think of an artificial brain seems to compel us to think of a man without mind, a mere automaton. Can science help us here? It must suffice to refer to a single type of experiment, recorded by Professor Haldane.†—" An American surgeon has studied the effect on several people,

* See Chap ix, § 9

† *The Mysteries of Life and Death*, p. 41.

including his own sister, of removing large parts of the front of the brain after injury or the growth of a tumour. This causes no appreciable loss of sensation, memory, or muscular power, but there is a very real loss of initiative. One patient could look after her household on ordinary occasions, but could not order a large dinner; another could keep a simple job but could not see about looking for a new one. ' He will never make a revolutionary ', says our author." . . . " As the brain is destroyed, the personality gradually fades out,—a baby born with no upper parts to its brain shows less signs of consciousness than a fish, let alone a rabbit or a dog, though it may live for a year."

Professor Haldane thus infers that brain surgery is against the hypothesis that an indivisible something, " the soul ", leaves the body at the moment of death. " If there is a detachable soul, it can certainly be detached bit by bit, and all that is specifically human in it may be lost long before death."

The actual moment of death is often uncertain. Artificial respiration can sometimes yield a few more minutes of life after " the last breath ", and a surgeon can sometimes restore the circulation for a short time by suitably massaging the heart. Death is essentially a gradual process, and some of the cells of the body may live on for hours or days. If the heart be taken from a rabbit just killed by a blow on the head, it may, under suitable conditions, go on beating for some hours. The heart is alive though its owner is dead.

The moment must come when the very last cell of a body dies. If a human body, that wonderfully organized conscious machine, has thus completely run down and all its activity has ceased, what has become of its memory, its will-power, its passions? What has become of the personality, call it " self " or " soul " or what we may? Can we conceive of the " self " as decomposable into its parts, as brain-surgery suggests, or is it something quite independent of the body and indestructible? The most paradoxical and abnormal thing in the whole realm of nature is *the production of such a*

thing as consciousness in the brain. The problem is the greatest of all world-enigmas. The two things " consciousness " and " brain " seem to represent such altogether heterogeneous natures.

What is the key to the riddle? We simply do not know. The mechanist and the idealist, the physicist and the biologist, the philosopher and the theologian, they all have their solutions. The solutions for which we feel some respect we gravely refer to as " hypotheses ", those which do not appeal to us we impatiently refer to as wild " guesses ". But what is the basic difference between them?

Nature has certainly given us at least one problem which we cannot at present hope to solve.

5. The Soul: What? Whence? Where? Whither?

Is it preferable to say that man *has* a soul or that he *is* one? The term " soul " has become so ambiguous that it might well be abandoned altogether, and we might perhaps speak of the " self " or of the " person " or of the " ego " instead. " Mind " is a more vague term. If a child of five lives to be fifty, he is the same *self*, but how marked are the differences—the thoughts, the memories, the will, the passions. What is it that develops? The body, of course. But what is the nature of that other identity which thinks and remembers, loves and hates? And is this other identity separable from the body at death, and does it survive and live on and on, absolutely defying all physical laws? If it survives in this way, what actually happens at death—does it sleep as so many tombstones assert, or is it immediately judged? If it sleeps, what a long, long sleep! If it is judged, what is the relation of this preliminary judgment to the Last Judgment?

On this general question the Christian religion helps us very little. The Church apparently supports the doctrine of a future life, but its assurances are anything but explicit. Moreover it raises insoluble difficulties. In short, such argu-

ments in favour of a future life as are based on authority are profoundly inconclusive.

That my body influences my self much and continuously admits of no denial; and that my mind (the self) acts on my body also admits of no denial; and in both cases all the effects could be easily explained on the hypothesis that the self and the body were two separate realities, neither of which was produced by the other but both standing on an equal footing. But there has always been a strong tendency on the part of thinking men to adopt the view that the self is a mere activity of the body and has been produced by the body. Body is *matter*, and self is *spirit*, and any hypothesis that makes either spirit or matter the sole reality in the universe provides a unity which gives many people great intellectual satisfaction; they prefer monism to dualism, whether the monism is mechanism or idealism.

Of the two monisms, materialistic monism is more plausible than idealistic monism—that matter is the only reality and that spirit is nothing more than one of its manifestations; matter seems to be so independent of man's will; it seems so vast and to be never-ending in time; whereas spirit we only know in the form of separate individuals, set in the midst of matter, and never surviving much beyond a century. But the arguments on the other side are almost equally strong. No justification for the belief in the independent existence of matter is available except the sensations; we never believe that we are observing matter unless we are experiencing sensations more or less analogous to the qualities we believe to exist in the matter. The matter itself, if it exists, is *inferred*.

In short, each type of monism tries to explain away the other, but it fails, and we therefore seem to be left with dualism, though this is equally inexplicable. Yet *if* there are both a soul and a body, *if* these are separable, *if* the body is merely a temporary home of the soul, many of the difficulties of the doctrine of immortality disappear, though how a separable soul can dwell in the living body is utterly incon-

ceivable. That difficulty is very great, but if the self is a mere activity of the body, it would be impossible that it should continue to exist when the body has ceased to exist, and the idea of immortality then becomes absurd.

Admittedly we are profoundly ignorant of the bond which links the soul and body. We are also profoundly ignorant of the nature of the soul, but we may, at least temporarily, put forward the hypothesis that the soul *exists.* In that case we seem to have no option but to adopt one of three alternatives: either the soul must have been specially created by the Deity, or it must have been derived from the souls or bodies of its parents, or it must have existed before the body. Thus we have a choice of Creationism, Traducianism, and Pre-existence.

One difficulty about *Creationism* is that it fails to explain why the Creator should have conferred upon different souls such extraordinarily different dispositions and faculties. How can the creation of souls with different endowments be compatible with divine justice, especially the justice to be meted out on the Church's Day of Judgment?

A difficulty about *Traducianism* * is to decide precisely when the soul, as distinct from the body, was born. The birth of the human being is commonly supposed to take place at parturition, but that is a quite arbitrary choice of time. Actually it normally takes place some nine months before, on the fusion of the two microscopic parental cells. In that slowly developing body from such a simple physical beginning, when does consciousness begin? when is the first dawn of rationality? Is the soul born then? What sort of a being was that half-brutish ancestor of ours which first received a soul? If we *knew* that, how *much* we should know! Dare we draw a fine line between intelligent animals and primitive man? It seems impossible to decide exactly when immortality begins, either in the beginning of the individual's life or in the life of the race.

* The doctrine that both the soul and the body of man are propagated (Lat. *traducere* = to propagate).

Pre-existence is the doctrine that if man is immortal, it is probable that the beginning of his present life was not the beginning of his whole existence but that he lived before it as he will live after it. If pre-existence could be proved, the argument for immortality would be enormously strengthened. But one objection seems to be fatal: we none of us have the faintest glimmering of a memory of a former life. Further, if, as seems to be established, we inherit our characters and dispositions from our parents, how can those characters and dispositions be derived from a pre-existent ego of our own? In short, both memory and heredity seem fatal to the doctrine of pre-existence, though some of our ablest philosophers have defended it and have made it the basis of their chief argument in favour of the doctrine of immortality generally.

If we are willing to surrender the idea of *personal* immortality, the advancement of a more satisfactory hypothesis becomes easily possible. We may then regard the bodily feelings as transitory, and distinguish between the mortal and immortal " parts of the soul ", though naturally the distinction seems to destroy the self, the human personality; " and the 'immortal' part is left as an empty shell from which all content has been extracted, which has no feeling that anyone ever feels or is capable of feeling, and is nothing the continuance of which human feeling can possibly desire." Nothing then remains to distinguish one person's soul from that of another, and so " the immortal part is declared to be the Universal Soul in which all the individual souls partake and which is one and the same for all. And whereas the personal individual souls are transitory, the impersonal Universal Soul is eternal." It is as if some small part of this universal spirit took possession of the newly-born child's brain, became its fellow-worker for the space of the child's life, and then departed whence it came. If *that* is the solution of the big problem, immortality means no sort of permanent *personal* survival.—Think of a raindrop falling into a mountain stream and returning to its ancestral ocean-home. As an individual drop it is perhaps lost for ever, and yet, though swallowed

up, it will survive as long as the world's water survives. The mountain stream remains, and so do the oceans, but the drop is now indistinguishable from myriads of others.—The parable affords but a very rough analogy, but it will serve.

Sometimes immortality is interpreted to mean the impress which a person's character and works make on those left behind him. From that point of view alone Christ is certainly immortal; His name and fame will survive as long as history endures. Of the great personages of antiquity, Plato and Aristotle are the most likely to endure for many ages to come, and of those of the last 2000 years men like Shakespeare and Newton. Great thinkers are always more likely to endure than great men of action. Military leaders like Alexander the Great and Napoleon will in the ages to come be associated merely with the semi-barbarism in which mankind were still struggling. In the history books of 50,000 years hence, how much space is likely to be given up to the dawn of historical time ending A.D. 2000? Half a page? Perhaps. Certain it is that the history of men and women who have made their mark will endure for long, but, as the ages pass, that history is bound to fade away gradually into an entirely irrecoverable past. The vast majority of men and women, who have led just a humdrum life in their own little circle, will *they* leave any history behind them? Perhaps in family tradition for a generation or two, though destined soon to fade away absolutely, in time, even from the old family Bible. Clearly "immortality", if the connotation of the term is not pressed too hard, has many degrees, and its significance many forms.

All people must have done *something* during their lives that has affected those with whom they were brought in contact, for good or for ill. Hence they are *remembered*, though the memory of them gradually fades and the good or the evil may be but transient.

This, however, is not the kind of immortality which the human race craves for. They want to live on and on, they want to remember all the good things of the old days, they

want to be restored to their friends, they want perpetual happiness. "To have a real meaning, immortality must be *personal* immortality, i.e. it must involve the persistence of the 'I' which in this life thinks, and feels, and wills. It must preserve our personal identity, that is there must be continuity of consciousness between the self of this life and of the next." "A future life without personal identity is a meaningless mockery." Does the Church assure us that at least our memory will be preserved? It does not. It cannot. It dare not. One of the ablest and most enlightened of our present bishops has recently said, "I think that man's personality survives the death of his body," and he refuses to commit himself further. He knows well that the arguments, *pro* and *con*, tend to cancel each other out and he shrinks from dogmatizing.

With that bishop's pronouncement I think we must be content.

Dr. James Hutchison Stirling* was a man who "held the conviction of immortality with particular intensity, yet he writes, 'We shall not speak of love or of science or of Shakespeare, but he who has seen the sea and the blue of heaven, and the moon and the stars, who has clomb a mountain, who has heard a bird in the woods, who has seen a sock or a shoe of his own child, who has known a mother—he will bow the knee and thank his God and call it good, even though his lot in the end be nothingness?' This is to see things in a truer proportion, and philosophy is largely a question of proportion. Personal immortality, as the history of the race abundantly shows, is not an absolute necessity, in the sense that without it the world becomes a sheer irrationality. There is certainly possible a disinterested devotion to ideals whose triumph, as we quite simply say, we shall not be there to see. We feel that we are sharers of a wider life and we feel that it is good to have been admitted to share it. . . . That our ideals should perish, that nothing

* See *His Life and Works*, p 251, quoted by Professor A. Seth Pringle-Pattison in *The Idea of God*, p. 45.

worth existing should have any pledge of continuance or growth, that is the one intolerable conclusion."

Why should we think of Heaven as a haven of idleness? Is it a healthy state of mind to yearn for a comfortable seat in a richly bejewelled concert hall—to look forward to listening to the strain of an orchestra for ever and for ever? The idea of having to live our present lives with a wireless receiving set that could not be turned off is simply appalling. If there is to be a future life, let us think of it as a life of new adventure, as an opportunity for fresh labours, as a time of possible new trials, but as a time of recompense, too. Would an absolutely idle life be worth while? The utter weariness and boredom of it! Would not complete annihilation be preferable to immortality if immortality means perpetual lounging with other loungers? "Would it not be worth much," as Dr. McTaggart said, "to be able to hope that what we misused in one life might come to us in another? And would it not be worth much to be able to hope that we might have a chance to succeed hereafter in the tasks we failed in here?"

The questions we asked, "What? Whence? Where? Whither? all remain unanswered. The Riddles remain unsolved. Nevertheless the mind seems constrained to hope, to look forward, and even to expect a new and great adventure. When men search into the unknown, especially when the unknown seems to be so absolutely unknowable, they naturally arrive at very different conclusions. All cannot be right. All may be wrong. It is an impressive fact that down the ages there has always been an impulse to search for a proof of immortality, and it may be, as Emerson said, that this impulse is the strongest proof of all that the self does really survive, though precisely how we can never know.

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CHAPTER XIV

Belief and Truth

1. Obsession and Conviction

The term *obsession* is derived from Lat. *obsessus*, besieged, the p.p. of *obsidere* (*ob*, before; *sedere*, to sit). But a secondary and commoner meaning was *besieged by an evil spirit*, and the two terms *possession* and *obsession* came to be contrasted in this way: *possession* signified control by the evil spirit *from within*; *obsession*, control by the evil spirit *from without*. Demoniacal possession was once a widely spread explanation of such psycho-pathological conditions as epilepsy and hysteria, and it is familiar enough in New Testament narratives. Obsession, at first representing the besieging effort of an outside evil spirit to obtain mastery of a person, eventually came to signify the state or condition of a person thus besieged or beset. Nowadays a person is said to be "obsessed" with an idea when the idea not only besets him but holds him as in a vice, torments him continually, and compels him to subordinate everything else to its defence.

Conviction is a term much less suggestive of such complete irrationality. It connotes a state of being convinced or fully persuaded, or a strong belief on the ground of satisfactory reasons or evidence; it implies conscious assent of the mind, or settled persuasion. In his *Grammar of Assent*, Newman maintained that conviction is a word which commonly includes in its meaning two distinct acts—the act of inference and the act of assent consequent upon the inference. From this it might be inferred that convictions are the result of

rational processes, but they are certainly not always the result of *conscious* rational processes.

2. Belief and Truth

It has often been said that truth is a many-faceted diamond, and the reader will find it profitable to ponder over the opinions of different thinkers on the nature both of truth and of belief, and of their inter-relations. We give some extracts from the works of a few well-known men, all of them recognized as authorities in their respective departments of thought.

(i) Lord Balfour

Arthur James Balfour (1848–1930) was admittedly one of the really distinguished intellectual men of his generation. On his father's side he traced descent from Robert the Bruce; his mother was a Cecil, the sister of the distinguished Prime Minister, Lord Salisbury. The Cecilian temperament, which with its blend of boldness and caution, of critical detachment and intellectual passion, has played such a momentous part in English history since the reign of Queen Elizabeth, " achieved in Arthur Balfour one of its most brilliant incarnations ". He was very far from being a cynic or a sceptic, as superficial critics have sometimes said. " His was a mind almost painfully exercised about the ultimate riddles of the universe, a soul fortified by deep, if not easily definable, religious convictions, a nature that drew its spiritual nutriment both in literature and in music from the highest and gravest sources, and a spirit animated by an unsleeping sense of public duty ". His range of knowledge was astonishing, and, when the British Association for the Advancement of Science made him their President they were tremendously impressed by the way in which he dug down to the bed-rock foundations of their own subjects. In his books he made a

strenuous and successful attempt to set in a clear light the presuppositions of science, of philosophy, and of religion.

We quote from three:

From *A Defence of Philosophic Doubt.*

" Since all beliefs are caused, it follows that those fundamental beliefs must be caused which lie at the root of all other beliefs, and which are the rational ground on which we hold them. Now these fundamental beliefs, being the ultimate premisses of all knowledge, are themselves, of course, incapable of proof. So that while they resemble other beliefs in being caused, they differ from them in this, that the causes by which they are produced are of necessity, and, from the very nature of the case, always non-rational. In ordinary life, when we perceive a non-rational cause for any opinion, as for instance party feeling, or self-interest, or special education, it makes us examine such reasons as there may be for it with more jealous minuteness. In contrast to this, it is curious and interesting to note that the only beliefs of which, according to received scientific theories, we may say with certainty that they can have no reason, but must have non-rational causes, are those on which the certitude of all other beliefs finally rests."

" If any result of ' observation and experiment ' is certain, this one is so—that many erroneous beliefs have existed, and do exist in the world; so that whatever causes there may be in operation, by which true beliefs are promoted, they must be either limited in their operation or be counteracted by other causes of an opposite tendency. Have we then any reason to suppose that fundamental beliefs are specially subject to these truth-producing influences, or specially exempt from causes of error? This question, I apprehend, must be answered in the negative. At first sight, indeed, it would seem as if those beliefs which are the results of legitimate reasoning were specially protected from error. But legitimate reasoning is only a protection against error if it proceeds

from true premisses, and it is clear that this particular protection the premisses of all reasoning never can possess."

"No system of beliefs, giving an account of the origin of fundamental beliefs, can be consistent unless those fundamental beliefs are as certain, when regarded as the result of antecedent causes, as they are when regarded as the ground of our belief in the existence and operation of those causes. It does not follow that if, according to the account of their origin given by the system, those fundamental beliefs are true, *that therefore they are true*; for the truth of the system is an inference from these beliefs, and cannot therefore prove them."

"Ultimate premisses are not shown to be merely probable by one set of proofs, and shown to be certain by another. They are not shown to be certain at all. They are assumed to be so: and the first stage of the difficulty arises from the fact that while they are assumed without evidence to be certain, the evidence we possess as to their origin shows that they are *not* certain. . . . It is at the next stage that the real difficulty arises, when we consider the fact that our whole ground for thinking these ultimate premisses doubtful is founded in the last resort upon their certainty."

"The difficulty only arises, it may be observed, when we are considering our own beliefs. If I am considering the beliefs of some other person—say of some mediæval divine—there is no reason why I should regard them as anything but the results of his time and circumstances. I observe that he lived in such a country, fell under the influence of such and such teachers, came across such and such incidents, and then I infer, with much self-contentment, that his beliefs could not have been other than they were. I may even pay them the compliment of pointing out that they form a necessary stage in the general evolution of humanity. But when I come to consider my own beliefs as a stage in the general evolution of humanity, then there emerges the contradiction mentioned above. If they represent such a stage, all of them may be, and many of them must be, false."*

* *op. cit.*, from pp. 263–8.

From *Theism and Humanism.*

" I must call your attention to a double aspect possessed by all beliefs alike, whatever be the subject-matter with which they deal. All beliefs have a position, actually or potentially, in a cognitive series; all beliefs, again, have a position, known or unknown, in a causal series. All beliefs, in so far as they belong to the first kind of series, are elements in one or more collections of interdependent propositions. They are conclusions, or premisses, or both. All beliefs, in so far as they belong to the second kind of series, are elements in the temporal succession of interdependent events. They are causes, or effects, or both.

" It has further to be noted that whereas reasons may, and usually do, figure among the proximate causes of belief, and thus play a part in both kinds of series, it is always possible to trace back the causal series to a point where every trace of rationality vanishes; where we are left face to face with conditions of beliefs—social, physiological and physical —which, considered in themselves, are quite a-logical in their character.

" It is on this last point that I particularly desire to insist. We are all very familiar with the equivocal origin of most human creeds. To be sure, we observe it chiefly in the case of other people. In our own case, we dwell by preference on those causes of our beliefs which are also reasons. But in our detached studies of the opinions we do not share, we easily perceive how insufficient are the arguments officially urged on their behalf, and how often even these insufficient arguments have only a nominal connexion with the convictions of which they claim the legal paternity."*

From *The Foundations of Belief.*

" Our ancestors, whose errors we palliate on account of their environment with a feeling of satisfaction, due partly to our keen appreciation of our own happier position and

* *op. cit.*, pp. 46–7.

greater breadth of view, were not to be pitied because they reasoned little and believed much; nor should we necessarily have any particular cause for self-gratulation if it were true that we reasoned more and, it may be, believed less. Not thus has the world been fashioned. But, nevertheless, this identification of reason with all that is good among the causes of belief, and authority with all that is bad, is a delusion so gross and yet so prevalent that a moment's examination into the exaggerations and confusions which lie at the root of it may not be thrown away.

"The first of these confusions may be dismissed almost in a sentence. It arises out of the tacit assumption that reason means right reason. Such an assumption, it need hardly be said, begs half the point at issue. Reason, for purposes of this discussion, can no more be made to mean right reason than authority can be made to mean legitimate authority. True, we might accept the first of these definitions, and yet deny that all right belief was the fruit of reason. But we could hardly deny the converse proposition, that reason thus defined must always issue in right belief. Nor need we be concerned to deny a statement at once so obvious and so barren."

"Though it be true, that the importance of reason among the causes which produce and maintain the beliefs which form the groundwork of life has been much exaggerated, there can yet be no doubt that reason is, or appears to be, the cause over which we have the most direct control. We are acted on by authority. It moulds our ways of thought in spite of ourselves, and usually unknown to ourselves. But when we reason we are the authors of the effect produced. We have ourselves set the machine in motion. For its proper working we are ourselves immediately responsible; so that it is both natural and desirable that we should concentrate our attention on this particular class of causes."

"The 'spirit of the age' is one form in which authority most potently manifests itself. Dogmatic education in early years may do much. The immediate pressure of domestic,

social, scientific, ecclesiastical surroundings in the direction of specific beliefs may do even more. But the power of authority is never more subtle and effective than when it produces a psychological 'atmosphere' or 'climate' favourable to the life of certain modes of belief, unfavourable, and even fatal, to the life of others. Such 'climates' may be widely diffused, or the reverse. Their range may cover a generation, an epoch, a whole civilisation, or it may be narrowed down to a sect, a family, even an individual."

"Authority as contrasted with Reason, stands for that group of non-rational causes, moral, social and educational, which produces its results by psychic processes other than reasoning. But many of these non-rational causes can be converted into reasons without seeming at first sight thereby to change their function as channels of Authority; and so convenient is this method of bringing these two sources of conviction on to the same plane, so perfectly does it minister to our instinctive desire to produce a reason for every challenged belief, that it is constantly resorted to, without apparently any clear idea of its real import, both by those who regard themselves as upholders and those who regard themselves as opponents of Authority in matters of opinion. To say that I believe a statement because I have been taught it or because my father believed it before me, or because everybody in the village believes it, is to announce what everyday experience informs us is a quite adequate cause of belief—it is not, however, *per se*, to give a *reason* for belief at all. But such statements can be turned at once into reasons by no process more elaborate than that of explicitly recognizing that my teachers, my family, or my neighbours, are truthful persons, happy in the possession of adequate means of information—propositions which in their turn, of course, require argumentative support. Such a procedure may, I need hardly say, be quite legitimate; and reasons of this kind are probably the principal ground on which in mature life we accept the great mass of our subordinate scientific, and historical convictions. I believe, for instance, that the moon falls in towards

the earth with the exact velocity required by the force of gravitation, for no other reason than that I believe in the competence and trustworthiness of the persons who have made the necessary observations and calculations. In this case the reason for my belief and the immediate cause of it are identical; the cause, indeed, is a cause only in virtue of its being first a reason. But in the former case this is not so. Mere early training, paternal authority, or public opinion, were causes of belief before they were reasons; they continued to act as non-rational causes after they became reasons; and it is not improbable that to the very end they contributed less to the resultant conviction in their capacity as reasons than they did in their capacity as non-rational causes."

"No agreement about theological or any other doctrine insures, or, indeed, is capable of producing, sameness of belief. We are no more able to believe what other people believe than to feel what other people feel. Two friends read together the same description of a landscape. Does anyone suppose that it stirs within them precisely the same quality of sentiment, or evokes precisely the same subtle associations? And yet, if this be impossible, as it surely is, even in the case of friends attuned, so far as may be, to the same emotional key, how hopeless must it be in the case of an artist and a rustic, an Ancient and a Modern, an Andaman islander and a European! But if no representation of the splendours of Nature can produce in us any perfect identity of admiration, why expect the definitions of theology or science to produce in us any perfect identity of belief? It may not be. This uniformity of conviction, which so many have striven to attain for themselves, and to impose upon their fellows, is an unsubstantial phantasm, born of a confusion between language and the thought which language so imperfectly expresses. In this world, at least, we are doomed to differ even in the cases where we most agree."

"The doctrines of science have not got to be discussed amid the confusion and clamour of the market-place; they stir neither hate nor love; the fortunes of no living polity

are bound up with them; nor is there any danger lest they become petrified into party watchwords. Theology is differently situated. There the explanatory formula may be so historically intertwined with the sentiments and traditions of the ecclesiastical organization; the heat and pressure of ancient conflicts may have so welded them together, that to modify one and leave the other untouched seems well-nigh impossible. Yet even in such cases it is interesting to note how unexpectedly the most difficult adjustments are sometimes effected; how, partly by the conscious, and still more by the unconscious, wisdom of mankind; by a little kindly forgetfulness; by a few happy inconsistencies; by methods which might not always bear the scrutiny of the logician, though they may well be condoned by the philosopher, the changes required by the general movement of belief are made with less friction and at a smaller cost—even to the enlightened —than might, perhaps, antecedently have been imagined."*

(ii) Frederick Temple, Archbishop of Canterbury.

Temple (1821–1902) was a Balliol man who threw in his lot with the "Oxford Liberal Movement" rather than with the "Tractarian Movement". From 1855 to 1858 he was one of H.M. Inspectors of Elementary Schools and was then appointed Headmaster of Rugby where he liberalized the curriculum and dared to uproot some of the old traditions of the playing fields. Before he was forty he contributed an essay to one of the most notable books of the nineteenth century, *Essays and Reviews*, viz: *The Education of the World.* The tolerance and the liberal-mindedness of the Essayists roused a tremendous storm, and when Gladstone appointed Temple Bishop of Exeter in 1869, the storm broke out with increased violence. Pusey revealed the inner nature of his own Christianity when he declared that the choice of Temple "was the most frightful enormity ever perpetrated by a

* *op. cit.*, from pp. 202, 203, 205–6, 219–21, 261–2, 275–6.

Prime Minister." Temple was translated to London in 1885, and passed on to Canterbury in 1896. He was one of the greatest archbishops that Canterbury has ever had.—We quote from his famous Essay:

"The youth, when too old for discipline, is not yet strong enough to guide his life by fixed principles. He is led by his emotions and impulses. He admires and loves, he condemns and dislikes, with enthusiasm. And his love and admiration, his disapproval and dislike, are not his own, but borrowed from his society. He can appreciate a character, though he cannot yet appreciate a principle. He cannot follow what his heart does not love as well as his reason approve; and he cannot love what is presented to him as an abstract rule of life, but requires a living person. He instinctively copies those whom he admires, and in doing so imbibes whatever gives the colour to their character. He repeats opinions without really understanding them, and in that way admits their infection into his judgment. He acquires habits which seem of no consequence, but which are the channels of a thousand new impulses to his soul. If he reads, he treats the characters that he meets with in his book as friends or enemies, and so unconsciously allows them to mould his soul.

"At the meeting point of the child and the man, the brief interval which separates restraint from liberty, young men are learning a peculiar lesson. They seem to those who talk to them to be imbibing from their associates and their studies principles both of faith and conduct. But the rapid fluctuations of their minds show that their opinions have not really the nature of principles. They are really learning, not principles, but the materials out of which principles are made. They drink in the lessons of generous impulse, warm unselfishness, courage, self-devotion, romantic disregard of worldly calculations, without knowing what are the grounds of their own approbation, or caring to analyse the laws and

ascertain the limits of such guides of conduct. They believe, without exact attention to the evidence of their belief; and their opinions have accordingly the richness and warmth that belong to sentiment, but not the clearness or firmness that can be given by reason. The opinions now picked up, apparently not really, at random, must hereafter give reality to the clearer and more settled convictions of mature manhood. If it were not for these, the ideas and laws afterwards supplied by reason would be empty forms of thought, without body or substance."

"Toleration is the very opposite of dogmatism. It implies in reality a confession that there are insoluble problems upon which even Revelation throws but little light. Its tendency is to modify the early dogmatism by substituting the spirit for the letter, and practical religion for precise definitions of truth. This lesson is certainly not yet fully learnt. Our toleration is at present too often timid, too often rash, sometimes sacrificing valuable religious elements, sometimes fearing its own plainest conclusions. Yet there can be no question that it is gaining on the minds of all educated men, whether Protestant or Roman Catholic, and is passing from them to be the common property of educated and uneducated alike. There are occasions when the spiritual anarchy which has necessarily followed the Reformation threatens for a moment to bring back some temporary bondage, like the Roman Catholic system. But on the whole the steady progress of toleration is unmistakable. The mature mind of our race is beginning to modify and soften the hardness and severity of the principles which its early manhood had elevated into immutable statements of truth. Men are beginning to take a wider view than they did. Physical science, researches into history, a more thorough knowledge of the world we inhabit, have enlarged our philosophy beyond the limits which bounded that of the Church of the Fathers. And all these have an influence, whether we will or no, on our determinations of religious truth. There are

found to be more things in heaven and earth than were dreamt of in the patristic theology. We can acknowledge the great value of the forms in which the first ages of the Church defined the truth, and yet refuse to be bound by them; we can use them, and yet endeavour to go beyond them."

"To learn toleration well and really, it is absolutely necessary that it should break in upon the mind by slow and steady degrees, and that at every point its right to go further should be disputed, and so forced to logical proof. For it is only by virtue of the opposition which it has surmounted that any truth can stand in the human mind. The strongest argument in favour of tolerating all opinions is that our conviction of the truth of an opinion is worthless unless it has established itself in spite of the most strenuous resistance, and is still prepared to overcome the same resistance, if necessary. Toleration itself is no exception to the universal law; and those who must regret the slow progress by which it wins its way, may remember that this slowness makes the final victory the more certain and complete. Nor is that all. The toleration thus obtained is different in kind from what it would otherwise have been. It is not only stronger, it is richer and fuller. For the slowness of its progress gives time to disentangle from dogmatism the really valuable principles and sentiments which have been mixed up and entwined in it."*

(iii) William Temple, Archbishop of York

William Temple (*b.* 1881), son of Archbishop Frederick Temple, has been Archbishop of York since 1929. His broad-minded views may be gauged from the following extracts from his little book *Christianity in Thought and Practice.*

"The scholastic philosophers of the golden Middle Ages exhibited the most astonishing thoroughness of intellec-

* *op. cit.*, from pp. 20–2, 43–4, 46–7.

tual inquiry; they were relentless in the pursuit of the argument and the detection of the minutest fallacy; and they ended by building up a scheme of thought so comprehensive and so close-knit that the intrusion into it of any considerable new range of fact was bound to break it in pieces. It had no elasticity, because it was so thorough in a logical sense. And consequently, when the experience of men began to widen and when there occurred that event which may be variously estimated as a boon or otherwise to mankind—the discovery of America—there was no room for such facts in the close-knit scholastic scheme, and it was broken with a completeness which has, I think, no parallel in the history of thought."

" The critical method of Kant, consists of inquiring what is involved in the assumptions or beliefs that are found to be commonly held, pressing back from anything which is accepted to ask what must be true in order that this also may be true.

" In spirit I think this is the same as the method of Plato, of recognizing that every truth that we reach is only a partial truth; that there will be some contexts in which it will appear false; and that we have to seek for those contexts in order to be further correcting and developing the truth which we have so far arrived at. . . . It is the attempt to reach truth by the putting of different points of view over against each other and trying to do justice to them all. It is the method which always refuses to dismiss any alleged fact or any widely held belief on the ground that it will not harmonize with theories already adopted. . . . It is always welcoming new material in the realm of experience or of thought in order to adjust its own system to the new matter."

" The valid process of thought, in its search for knowledge, is not to be found in a process of induction from supposedly observed facts, because it is quite certain that the facts have not been correctly observed; nor is it a system of deduction from supposedly assured premisses, for it is quite

certain that there are other premisses of which account ought to be taken, which are not yet known to us; but it is a process of working round and round the available material until it is found gradually to fit into place and make a coherent scheme; and whenever, with reference to any department of investigation, you have reached a really coherent and comprehensive scheme, there you have got the truth concerning it, so far as your study has yet taken you. You know that it will not be quite true if you are dealing with the real world, because the areas which you have left out of consideration must have some influence upon this which you have studied. . . . That is the method by which I believe that truth is normally found."*

(iv) Dr. William Ralph Inge

Dr. Inge (*b.* 1860) was for a quarter of a century Dean of St. Paul's, and has long been regarded as one of our ripest scholars, especially in the departments of philosophy and theology. Everything he writes is eagerly read. We quote from the *Conclusion* which he wrote for the collective work, *Science, Religion and Reality*.

" I have treated the religion of Christ as one of the permanent achievements or acquisitions of humanity like Hellenism and the Roman science of law and government. There are few scientific men, in this country at least, who would not allow so much as this, though the question remains how much of traditional Christianity is essential, and how much an accretion or an accommodation to transient conditions. I shall not hide my convictions that some parts of the tradition are not integrally connected with the kernel of Christ's religion."

" It is right that we should remember that we stand in the middle—or perhaps nearer the beginning than the end—

* *op. cit.*, from pp. 17–20.

of a long evolutionary process, and that our thoughts and beliefs are determined by the period at which we live. Our civilization has its distinguishing characteristics, like the civilization of classical antiquity, or of the Middle Ages. We are what the past has made us; and if we can trace certain changes slowly at work in the period preceding our own we may be able to predict with some probability that these changes will continue, for some time at least, to operate in the same direction. The study of early history is certainly far more instructive in religion than in science. The rudimentary science which may be discovered even among savages is not interesting or important to modern research, which discards obsolete hypotheses without scruple or sentiment. The case is very different with religion, if we allow the word to include myth, ritual, and magic, through which religion has maintained its position as a social force. Religion is a powerful antiseptic, which preserves mummified customs that have long outlasted their usefulness, and otiose dogmas that have long lost their vitality." *

" Organized religion is not, in modern times, one of the strongest forces in human affairs. As compared with patriotism and revolutionary aims, it has shown itself lamentably weak. The strength of Christianity is in transforming the lives of individuals—of a small minority, certainly, as Christ clearly predicted, but a large number in the aggregate. To rescue a little flock, here and there, from materialism, selfishness, and hatred, is the task of the Church of Christ in all ages alike, and there is no likelihood that it will ever be otherwise. To many the most pressing question is whether the Churches will ever make it easier for students of science to profess themselves church-members without doing violence to their scientific conscience. What the institutions will decide is quite uncertain. But there are already large numbers of Christians who find it possible to follow Christ while accepting the conclusions of science and the scientific

* *op. cit.*, pp. 348–9.

attitude of mind. These are far more important than their isolation from ecclesiastical life might lead us to suppose. It is to individuals that we must look for encouraging signs, not to institutions. Science has learned this lesson in its own sphere; it must look at religion in the same way. The right note was already struck at the Renaissance. Leonardo da Vinci exclaims: 'Let bigots talk at leisure and heed them not. The study of Nature is well-pleasing to God, and is akin to prayer. Learning the laws of Nature, we magnify the first Inventor, the Designer of the world; and we learn to love him, for the great love of God results from great knowledge. Who knows little, loves little. If you love the Creator for the favour you expect of Him, and not for His most high goodness and strength, wherein do you excel the dog, who licks his master's hand in the hope of dainties? But reflect how that worthy beast, the dog, would adore his master if he could comprehend his reason and his soul.' Whether our dogs would respect us more if they knew us better may be seriously doubted; but I think we may say of natural science what Bacon said of philosophy, that while a little knowledge often estranges men from religion, a deeper knowledge brings them back to it; though we ought to add that the religion to which deeper knowledge brings us is not the same as that from which superficial knowledge estranges us."*

(v) Professor Silvanus P. Thompson

Silvanus P. Thompson (1851–1916) was a distinguished physicist who in character was so modest and unassuming that few people knew of his great gifts and his rare attainments in various departments of knowledge. Here is a reported instance of his versatility: he once gave a lecture before a learned audience in Berlin, speaking in German; he travelled directly to Rome and delivered the same lecture, speaking in Italian; and it is said that in both cases he spoke without notes. It is given to few men to lead such a blameless

* *ibid.*, pp. 388–9.

and lovable life as he did. We quote from his *The Quest for Truth*, the Swarthmore Lecture of 1915:

" Every student of the science of language knows full well how words, in passing as the current coin of thought from man to man, slowly change their meaning, so that to one generation they convey a slightly different implication from that which they conveyed to the preceding generation. Yet in one and the same age a word may mean very different things to different minds, even when the word itself is used carefully and in an accepted meaning. That language may change in the course of a century or two, may be seen by very simple examples from our own Authorized Version, in words which have altered their meanings since the time of King James. The " compass " which Paul and his companions " fetched " from Syracuse when sailing to Rhegium, was not the useful instrument of navigation that now goes by that name. When Christ ' prevented ' Peter, as we read in the account of the payment of the tax, the word as used in the seventeenth century meant ' anticipated ', and did not mean ' hindered ' as it now does. Words are in many instances fossil expressions of thought, which we do not understand until we have examined the significance they bore at the time when they were used. The philosophical Greeks in the period when Greek literature flourished were much more precise in defining and using words than were the later Greeks, including the writers of the New Testament. Yet even they were not always agreed as to the meanings attached to terms. Men who were careless about settling definitions left legacies of confusion to after ages. Half the theological disputes which raged in the Church from the third to the fifth century really turned upon the meanings of words; and anathemas were pronounced against men of piety because of misunderstandings of language. The theologians who were responsible for drawing up the three orthodox Creeds sinned greatly against the generations to come, by their morbid word-battlings respecting such words as ' person ' and ' substance ',

sometimes maintaining that their signification was the same, sometimes contending that they were essentially different.

"Orthodox theologians are most emphatic that it is a heresy either to confound the three 'persons' of the Trinity or to divide its 'substance' into three. Yet the Council of Nicæa decided that 'person' and 'substance' are the same. Dean Stanley, discussing that decision, quotes J. H. Newman as saying: 'its language is so obscure that even theologians differ about its meaning.' Dogmas, once the expression of ardent and living piety, have largely shrunk to mere formulas."

"Let us return to the quest for truth, and consider the things that militate against it—the feelings and preoccupations which tend against enquiry.

1. First, there is over-respect for venerated authority; the excessive deference to those whom we rightly revere, and to the sanctions of long-established custom.

2. Secondly, there is a false humility which blinds men from exercising any independent judgment.

3. Thirdly, there is in many minds an aversion from doubt; they dislike to have their judgment kept in suspense. They want to have their minds made up, even if the materials for arriving at a sound judgment are wanting.

4. Fourthly, there is a tendency to temporize; to accept the expedient, rather than share the toil of investigating the evidence. Habitual neglect of the faculty of discriminating the false from the true, the doubtful from the well-established, will bring atrophy of the power of discrimination.

5. Fifthly, and happily rare, is that opposition to truth which arises from the craving for originality.

6. Carelessness of phrase, inexactness in the habitual use of language, want of precision and clarity of thought, all militate against the apprehension of truth."

"What we desire to find is nothing else than the Truth itself; not some one phase of it that would be agreeable to

us, but the Truth for its own sake. Let us make very sure that whatever harm may come to us from error in history or in science, from accepting as true the garbled history or the sophisticated science, a thousand-fold harm will come to us if in the vital issues of faith and morals we are any the less scrupulous, or palter with the Truth. In each domain there exists its own besetting weakness: in history, the tendency to romance; in science, to agnosticism; in religion, to credulity. Is it any greater sin to reject a doubtful thing because it is doubtful, than to accept a doubtful thing on the off-chance that it may hereafter be found true? Surely in matters of religious belief we ought to make it our business to be as clear in vision, as pure in heart, as cool in head, as we would be in any other matter. Casuistry is even more deadly in religion than in history or science. The caution is necessary because the habitual ecclesiastical temper is to deprecate all independent enquiry, and to side with authority rather than face the facts."

"Think of the kind of argument by which the Fathers sought to justify the accepted views of the Church. According to *Irenaeus* there could be only four Gospels, because there were only four winds of heaven, and four quarters of the earth, and because the cherubim had only four faces apiece. *Saint Jerome*, wishing to clinch the doctrine that the resurrection would be a bodily one, asked most naively: If the dead be not raised, how could the damned, after the Judgment, gnash their teeth in hell?"*

(vi) Sir Leslie Stephen

Sir Leslie Stephen (1832–1904) was a notable Victorian man of letters. In his love of truth and his search for it he was utterly uncompromising. We quote from a chapter headed *Newman's Theory of Belief*, in one of his best-known works, *An Agnostic's Apology*:

* *op. cit.*, pp. 25–7, 34–6, 54–5, 100.

"**Newman** and **J. S. Mill** were nearly contemporaries; they were probably the two greatest masters of philosophical English in recent times, and yet they moved in spheres of thought so different that a critic, judging purely from internal evidence, might be inclined to assign them to entirely different periods. The distance from Oxford to Westminster would seem to be measurable rather in centuries than in miles. Oxford, as Newman says, was, in his time, a 'mediæval university'. Aristotelian logic still reigned supreme. To turn from Newman's 'Apologia' to Mill's 'Autobiography' is, in the slang of modern science, to plunge the organism in a totally different environment. With Newman we are knee-deep in the dust of the ancient Fathers, poring over the histories of Eutychians, Monophysites, or Arians, comparing the teaching of Luther and Melanchthon with that of Augustine; and from such dry bones extracting—not the materials of antiquarian discussions or philosophical histories—but living and effective light for our own guidance. The terminal limit of our inquiries is fixed by Butler's 'Analogy'. Newman ends where Mill began. It was precisely the study of Butler's book which was the turning-point in the mental development of the elder Mill, and the cause of his son's education in entire ignorance of all that is generally called religion. The foundation-stone of Mill's creed is to Newman the great rock of offence; the atmosphere habitually breathed by the free-thinker was to the theologian as a mephitic vapour in which all that is pure and holy mentally droops and dies. But, for the most part, Newman would rather ignore than directly encounter this insidious evil. He will not reason with such a man, but pass him by with an averted glance. 'Why,' he asks, 'should we vex ourselves to find out whether our own deductions are philosophical or no, provided they are religious?'

"That free play of the pure intellect, which with Mill is the necessary and sufficient guarantee of all improvement of the race, forms, according to Newman, the inlet for an 'all-corroding and all-dissolving' scepticism, the very poison of

the soul; for the intellect, when not subordinated to the conscience and enlightened by authority, is doomed to a perpetuity of fruitless wandering."

" In his sermons, Newman aims his sharpest taunts at the superficial optimism of the disciples of progress. In a phrase, quoted in the 'Apologia' with some implied apology for its vehemence, he states that it is his 'firm conviction that it would be a gain to this country were it vastly more superstitious, more bigoted, more gloomy, more fierce in its religion, than at present it shows itself to be.' The great instrument of his opponents is as objectionable as their end is futile and their temper shallow. The lovers of progress found their hopes on the influence of illumination in dispelling superstition. 'Superstition', replies Newman, 'is better than your so-called illumination.' Superstition, in fact, differs from religion, not in the temper and disposition of mind which it indicates, but in the authority which it accepts; it is the blind man groping after the guiding hand vouchsafed to him in revelation. 'To be superstitious is Nature's best offering, her most acceptable service, her most matured and enlarged wisdom, in presence of a holy and offended God'."

" Newman produced a Grammar of Assent instead of a logic; a theory of the methods by which men are convinced, not of the methods by which doctrines are proved: and an account of the assumptions upon which creeds in fact rest, rather than an account of the marks by which we may recognize the verified assumptions entitled to be regarded as established truths.

" So long as Newman remains within the limits thus prescribed, his theory appears to be as unassailable as it is admirably expounded. It is true, as he says, that 'formal logical sequence is not, in fact, the method by which we are enabled to become certain of what is concrete.' The real method is 'the cumulation of probabilities, independent of each other,

arising out of the nature and circumstances of the particular case which is under review: probabilities too fine to avail separately, too subtle and circuitous to be convertible into syllogisms, too numerous and various for such conversion, even were they convertible. As a man's portrait differs from a sketch of him in having not merely a continuous outline, but all its details filled in, and shades and colours laid on and harmonized together; such is the multiform and intricate process of ratiocination necessary for our reaching him as a concrete fact, compared with the rude operation of syllogistic treatment.' Nothing could be better said, or more substantially true. Formal logic is rather a negative and a verifying than a positive and discovering process, and represents only a very small part of the actual operation by which we are guided, and necessarily guided, in all practical judgments. When I form an estimate of a man's character, of the wisdom of a policy, of the truth of a creed, my mind is, in fact, determined by countless considerations, of which only a small part can be distinctly tabulated and drawn out into articulate logical order. But, undeniable as this may be, the logical formulæ may yet have a paramount importance. They do not constitute the whole line of defence, but they may give the key of the position."

[But though Newman's *method* may win approval, we have to think of the kind of intellectual food with which he was accustomed to feed himself:]

"Speaking of his former allies after his own conversion, Newman says, 'their scorn and their laughing-stock, was that imbecile, inconsistent thing called Protestantism.' The special ground of this scorn may be gathered from the 'Lectures on Justification'. Every page indicates the nature of the author's intellectual food. Extinct controversies are resuscitated; we plod through weary scholastic distinctions and refinements derived from our outworn metaphysical systems; and when reason, perplexed by these subtleties, fails to discriminate the blended elements of grace and nature,

we are ordered to prostrate ourselves before long chains of texts, where criticism would be profanity."

[It is pretty clear that Newman's " cumulation of probabilities " would nearly all go into the same scale-pan.]

" The whole mass of human belief may be regarded as a chaotic nebula surrounding a solid nucleus of definitely-established truth. The core of permanent knowledge consists partly in those beliefs which can be expressed with mathematical precision and exposed to definite tests, and partly in those vaguer and less tangible beliefs which may, nevertheless, be confirmed by such an overwhelming body of evidence from the concurrent testimony of innumerable observers that doubt is practically impossible. Outside this core we have multitudinous beliefs of all degrees of authority, down to the vaguest conjecture. But there is no definite separation between the inner and outer sphere. A process of integration is continually taking place. New beliefs are constantly crystallizing round the solid core and becoming definitely established, whilst others are dissipated or transformed by the progress of inquiry.

" Meanwhile it is an obvious fact that conviction follows a different law from proof. In many cases it outruns proof. A man may be as firmly convinced of the truth of an uncertain or a false proposition as of a demonstrable mathematical formula. He may be right, if he has evidence open to no one else, whether by virtue of finer perceptions or of fuller knowledge. Or, on the other hand, conviction may fall short of proof. A man may disbelieve an established proposition, either because he is ignorant of its evidence, or incapable of estimating the evidence, or too indolent or prejudiced to estimate it fairly. The question, therefore, as to whether a doctrine is proved is distinct from the question as to whether it produces conviction on a given mind. One problem is a logical one, and the other belongs to the theory of belief in general."*

* *op cit.*, pp. 168–70, 173–4, 209–10, 184, 213–5.

(vii) Professor William James

William James (1842–1910) one of America's leading philosophers, was well known in this country where his works and lectures immediately won for him the respect and esteem of our leading thinkers. We quote from his *The Meaning of Truth*:

"The 'laws of nature' were supposed to be exact, and exclusive duplicates of pre-human archetypes buried in the structure of things, to which the spark of divinity hidden in our intellect enables us to penetrate. Up to about 1850 almost everyone believed that sciences expressed truths that were exact copies of a definite code of non-human realities. But there are so many physical and chemical hypotheses, so many classifications, each one of them good for so much and yet not good for everything, that the notion that even the truest formula may be a human device and not a literal transcript has dawned upon us. Our mind has become tolerant of symbol instead of reproduction, of approximation instead of exactness, of plasticity instead of rigor.

"It is to be doubted whether any theorizer to-day, conceives himself to be literally re-editing processes of nature or thoughts of God. The main forms of our thinking are purely human habits; and many of our theological ideas are admitted, even by those who call them 'true', to be humanistic in like degree. Truth we conceive to mean everywhere, not duplication, but addition; not the constructing of inner copies of already complete realities, but rather the collaborating with realities so as to bring about a clearer result."

"In some men theory is a passion, just as music is in others. Such men systematize and classify and schematize and make synoptical tables and invent ideal objects for the pure love of unifying. Too often the results, glowing with 'truth' for the inventors, seem pathetically personal and artificial to bystanders."*

**op. cit.*, pp.57–60, 99.

(viii) William Kingdon Clifford

W. K. Clifford (1845–1879) was one of Cambridge's foremost mathematicians, and, for so young a man, a profound philosopher. Cambridge still remembers him as a particularly daring athlete. The following quotation is from his *Lectures and Essays*:

"A shipowner was about to send to sea an emigrant-ship. He knew that she was old, and not over-well built at the first; that she had seen many seas and climes, and often had needed repairs. Doubts had been suggested to him that possibly she was not seaworthy. These doubts preyed upon his mind, and made him unhappy; he thought that perhaps he ought to have her thoroughly overhauled and refitted, even though this should put him to great expense. Before the ship sailed, however, he succeeded in overcoming these melancholy reflections. He said to himself that she had gone safely through so many voyages and weathered so many storms that it was idle to suppose she would not come safely home from this trip also. He would put his trust in Providence, which could hardly fail to protect all these unhappy families that were leaving their fatherland to seek for better times elsewhere. He would dismiss from his mind all ungenerous suspicions about the honesty of builders and contractors. In such ways he acquired a sincere and comfortable conviction that his vessel was thoroughly safe and seaworthy; he watched her departure with a light heart, and benevolent wishes for the success of the exiles in their strange new home that was to be; and he got his insurance money when she went down in mid-ocean and told no tales.

"What shall we say of him? Surely this, that he was verily guilty of the death of those men. It is admitted that he did sincerely believe in the soundness of his ship; but the sincerity of his conviction can in no wise help him, because *he had no right to believe on such evidence as was before him.* He had acquired his belief not by honestly earning it in patient

investigation, but by stifling his doubts. And although in the end he may have felt so sure about it that he could not think otherwise, yet inasmuch as he had knowingly and willingly worked himself into that frame of mind, he must be held responsible for it.

"Let us alter the case a little, and suppose that the ship was not unsound after all; that she made her voyage safely, and many others after it. Will that diminish the guilt of her owner? Not one jot. When an action is once done, it is right or wrong for ever; no accidental failure of its good or evil fruits can possibly alter that. The man would not have been innocent, he would only have been not found out. The question of right or wrong has to do with the origin of his belief, not the matter of it; not what it was, but how he got it; not whether it turned out to be true or false, but whether he had a right to believe on such evidence as was before him.

"There was once an island in which some of the inhabitants professed a religion teaching neither the doctrine of original sin nor that of eternal punishment. A suspicion got abroad that the professors of this religion had made use of unfair means to get their doctrines taught to children. They were accused of wresting the laws of their country in such a way as to remove children from the care of their natural and legal guardians; and even of stealing them away and keeping them concealed from their friends and relatives. A certain number of men formed themselves into a society for the purpose of agitating the public about this matter. They published grave accusations against individual citizens of the highest position and character, and did all in their power to injure these citizens in the exercise of their professions. So great was the noise they made, that a Commission was appointed to investigate the facts; but after the Commission had carefully inquired into all the evidence that could be got, it appeared that the accused were innocent. Not only had they been accused on insufficient evidence, but the evidence of their innocence was such as the agitators might easily have

obtained, if they had attempted a fair inquiry. After these disclosures the inhabitants of that country looked upon the members of the agitating society, not only as persons whose judgment was to be distrusted, but also as no longer to be counted honourable men. For although they had sincerely and conscientiously believed in the charges they had made, yet *they had no right to believe on such evidence as was before them.* Their sincere convictions, instead of being honestly earned by patient inquiring, were stolen by listening to the voice of prejudice and passion.

"Let us vary this case also, and suppose, other things remaining as before, that a still more accurate investigation proved the accused to have been really guilty. Would this make any difference in the guilt of the accusers? Clearly not; the question is not whether their belief was true or false, but whether they entertained it on wrong grounds. They would no doubt say, 'Now you see that we were right after all; next time perhaps you will believe us.' And they might be believed, but they would not thereby become honourable men. They would not be innocent, they would only be not found out. Every one of them, if he chose to examine himself *in foro conscientiae*, would know that he had acquired and nourished a belief, when he had no right to believe on such evidence as was before him; and therein he would know that he had done a wrong thing.

"It may be said, however, that in both of these supposed cases it is not the belief which is judged to be wrong, but the action following upon it. The shipowner might say, "I am perfectly certain that my ship is sound, but still I feel it my duty to have her examined, before trusting the lives of so many people to her.' And it might be said to the agitator, 'However convinced you were of the justice of your cause and the truth of your convictions, you ought not to have made a public attack upon any man's character until you had examined the evidence on both sides with the utmost patience and care.'

"In the first place, let us admit that, so far as it goes,

this view of the case is right and necessary; right, because even when a man's belief is so fixed that he cannot think otherwise, he still has a choice in regard to the action suggested by it, and so cannot escape the duty of investigating on the ground of the strength of his convictions; and necessary, because those who are not yet capable of controlling their feelings and thoughts must have a plain rule dealing with overt acts.

"But this being premised as necessary, it becomes clear that it is not sufficient, and that our previous judgment is required to supplement it. For it is not possible so to sever the belief from the action it suggests as to condemn the one without condemning the other. No man holding a strong belief on one side of a question, or even wishing to hold a belief on one side, can investigate it with such fairness and completeness as if he were really in doubt and unbiased; so that the existence of a belief not founded on fair inquiry unfits a man for the performance of this necessary duty."*

(ix) James Anthony Froude

Froude (1818–1894) was one of the best-known historians of Victorian times. A little ruthless in his attacks on certain types of theologians, many theologians naturally disliked him and some of them hit back. But his Essay, *A Plea for the Free Discussion of Theological Difficulties*, which appeared in Frazer's Magazine in 1863, from which we quote, is persuasively argued and may be read with profit:

"As it is in idea essential to a reverence for truth to believe in its capacity for self-defence, so practically in every subject except one, errors are allowed free room to express themselves, and that liberty of opinion which is the life of knowledge, as surely becomes the death of falsehood. A method—the soundness of which is so evident that to argue in favour of it is almost absurd—might be expected to have

* *op. cit.*, Vol II, pp 177–81.

been applied as a matter of course to the one subject on which mistake is supposed to be fatal, where to come to wrong conclusions is held to be a crime for which the Maker of the universe has neither pardon nor pity. Yet many reasons, not difficult to understand, have long continued to exclude theology from the region where free discussion is supposed to be applicable. That so many persons have a personal interest in the maintenance of particular views, would of itself be fatal to fair argument. Though they know themselves to be right, yet right is not enough for them unless there is might to support it, and those who talk most of faith show least that they possess it. But there are deeper and more subtle objections. The theologian requires absolute certainty, and there are no absolute certainties in science. The conclusions of science are never more than in a high degree probable; they are no more than the best explanations of phenomena which are attainable in the existing state of knowledge. The most elementary laws are called laws only in courtesy. They are generalizations which are not considered likely to require modification, but which no one pretends to be in the nature of the cause exhaustively and ultimately true. As phenomena become more complicated, and the data for the interpretation of them more inadequate, the explanations offered are put forward hypothetically, and are graduated by the nature of the evidence. Such modest hesitation is altogether unsuited to the theologian, whose certainty increases with the mystery and obscurity of his matter; his convictions admit of no qualification; his truth is sure as the axioms of geometry; he knows what he believes, for he has the evidence in his heart; if he inquire, it is with a foregone conclusion, and serious doubt with him is sin. It is in vain to point out to him the thousand forms of opinions for each of which the same internal witness is affirmed. The Mayo peasant, crawling with bare knees over the flint points on Croagh Patrick, the nun prostrate before the image of St. Mary, the Methodist in the spasmodic ecstasy of a revival, alike are conscious of emotions in themselves which correspond

to their creed: the more passionate—or, as some would say—the more unreasoning the piety, the louder and more clear is the voice within. But these varieties are no embarrassment to the theologian. He finds no fault with the method which is identical in them all. Whatever the party to which he himself belongs, he is equally satisfied that he alone has the truth; the rest are under illusions of Satan."

"'What religion are you, Mr. Rogers?' said a lady once.

"'What religion, madam? I am of the religion of all sensible men.'

"'And what is that?' she asked.

"'All sensible men, madam, keep that to themselves.'

"If Mr. Rogers had gone on to explain himself, he would have said perhaps that when the opinions of those best able to judge are divided, the questions at issue are doubtful. Reasonable men who are unable to give them special attention withhold their judgment, while those who are able, form their conclusions with diffidence and modesty. But theologians will not tolerate diffidence; they demand absolute assent, and will take nothing short of it; and they affect therefore to drown in foolish ridicule whatever troubles or displeases them. The Bishop of Oxford talks in the old style of punishment. The Archbishop of Canterbury refers us to Usher as our guide in Hebrew chronology. The objections of the present generation of 'infidels', he says, are the same which have been refuted again and again, and are such as a child might answer. The young man just entering upon the possession of his intellect, with a sense of responsibility for his belief, and more anxious for truth than for success in life, finds when he looks into the matter that the Archbishop has altogether misrepresented it; that in fact, like other official persons, he had been using merely a stereotyped form of words, to which he attached no definite meaning. The words are repeated year after year, but the enemies refuse to be exorcised. They come and come again from Spinoza and Lessing to Strauss and Renan. The theologians

have resolved no single difficulty; they convince no one who is not convinced already."

(x) Bertrand Russell

Bertrand Russell (Earl Russell, *b.* 1872) the well-known Cambridge mathematician, logician, and philosopher, is the author of numerous works of permanent interest. We quote from *Our Knowledge of the External World.*

" The more thorough-going mystics do not employ logic, which they despise; they appeal instead directly to the immediate deliverance of their insight. Now, although fully developed mysticism is rare in the West, some tincture of it colours the thoughts of many people, particularly as regards matters on which they have strong convictions not based on evidence. In all who seek passionately for the fugitive and difficult goods, the conviction is almost irresistible that there is in the world something deeper, more significant, than the multiplicity of little facts chronicled and classified by science. Behind the veil of these mundane things, they feel, something quite different obscurely shimmers, shining forth clearly in the great moments of illumination, which alone give anything worthy to be called real knowledge of truth. To seek such moments, therefore, is to them the way of wisdom, rather than, like the man of science, to observe coolly, to analyse without emotion, and to accept without question the equal reality of the trivial and the important.

" Of the reality or unreality of the mystic's world I know nothing. I have no wish to deny it, nor even to declare that the insight which reveals it is not a genuine insight. What I do wish to maintain—and it is here that the scientific attitude becomes imperative—is that insight, untested and unsupported, is an insufficient guarantee of truth, in spite of the fact that much of the most important truth is first suggested by its means. It is common to speak of an opposition between instinct and reason; but in fact the opposition of

instinct and reason is mainly illusory. Instinct, intuition, or insight is what first leads to the beliefs which subsequent reason confirms or confutes; but the confirmation, where it is possible, consists, in the last analysis, of agreement with other beliefs no less instinctive Reason is a harmonizing, controlling force rather than a creative one. Even in the most purely logical realms, it is insight that first arrives at what is new."

3. Brevia: the same subject

1. " Prove all things."—*St. Paul* (I Thess. v. 21).

2. " Am I therefore become your enemy because I tell you the truth?"—*St. Paul* (Gal. iv. 16).

3. " Let every man prove his own work."—*St. Paul* (Gal. vi. 4).

4. " Strive for the truth unto death."—(Ecclesiasticus iv. 28.)

5. " Blame not before thou hast examined the truth: understand first, and then rebuke."—(Ecclesiasticus xi. 7.)

6. " It is only by virtue of the opposition which it has surmounted that any truth can stand in the human mind." —*Archbishop Trench.*

7. " It makes all the difference in the world whether we put truth in the first place or in the second."—*Archbishop Whateley.*

8. " In primis, hominis est propria veri inquisitio atque investigatio."—*Cicero* (*De Offic.*).

9. " La critique est la vie de la science."—*Cousin.*

10. " Truth emerges more quickly from error than from confusion."—*Bacon.*

11. "The more readily we admit the possibility of our own cherished convictions being mixed with error, the more vital and helpful whatever is right in them will become."—*Ruskin.*

12. "La vérité est toute pour tous."—*Courier.*

13. "He who wants to deceive mankind must before all things make absurdity plausible."—*Goethe.*

14. "'Tis with our judgments as our watches; none
Are just alike yet each believes his own."—*Pope.*

15. "While the theologians are searching for the keys of heaven, the simple wayfaring man lifts up the latch and walks in."—*Anon.*

16. "Much as the Christian minister inveighs against the ungodly world, his secret vexation is that he cannot clearly make it out to be as bad as his theology declares it to be."—*J. R. Seeley.*

17. "Reason commands us much more imperiously than a master; for in disobeying the one a man is unfortunate; in disobeying the other, he is a fool."—*Pascal.*

18. "The world is still deceived with ornaments.
In law, what plea so tainted and corrupt,
But, being season'd with a gracious voice,
Observes the show of evil? In religion,
What cursèd error, but some sober brow
Will bless it, and approve it with a text,
Hiding the grossness with fair ornament?"
—*Shakespeare* (*M. of V.*).

19. "A man may be a heretic in the truth; and if he believes things only because his pastor says so, or the assembly so determine, without knowing other reason, though his belief be true, yet the very truth he holds becomes his heresy."—*Milton* (*Areopagitica*).

20. "He who begins by loving Christianity better than truth, will proceed by loving his own sect or Church better than Christianity, and end in loving himself better than all." —*Coleridge.*

21. "God offers to every mind the choice between truth and repose. Take which you please—you can never have both. Between these, like a pendulum, a man oscillates. He in whom the love of repose predominates will accept the first creed, the first philosophy, the first political party he meets, and most likely his father's. He gets rest and reputation, but he shuts the door of truth. He in whom the love of truth predominates will keep himself aloof from all moorings, and afloat. He will abstain from dogmatism, and recognize all the opposite negations, between which, as walls, his being is swung. He submits to the inconvenience of suspense and imperfect opinion, but he is a candidate for truth as the other is not, and respects the highest law of his being."—*Emerson.*

22. "At the time of the Renaissance, mankind changed its authority, and this fact temporarily acted as an emancipation. But at the very commencement of the modern movement was the establishment of a reverential attitude towards any statement made by a classical author. Scholars became commentators on truths too fragile to bear translation. A science which hesitates to forget its founders is lost."—*Professor A. N. Whitehead.*

23. "Family, school, Church and State instruct the boy and the man what to think, and what to do. Inheriting a nature fit for such a life, his instincts of imitation, honour, sympathy, reverence, and the rest, all co-operate in delivering him over to the great tutor or arch-sophist (however you regard it), Society, till both in thought and manners—

> Custom lies upon him with a weight
> Heavy as frost and deep almost as life.

The habit of believing assertions becomes almost instinctive." —*Professor Carveth Read.*

24. "The use of the word *belief* in our language is changing: formerly it denoted something taken as definite and certain on the basis of some emotional authority; now it has grown rather to denote credit given to a statement on a more or less sufficient balancing of probabilities. Compare the older use in Biblical passages, e.g. 'Except ye see signs and wonders ye will not believe', with such modern usage, 'I believe that you will find a cab on the stand and that the train starts at half-past eight.' The change in usage marks the gradual transition of the basis of conviction from uncriticising faith to weighed probability."—*Professor Karl Pearson.*

4. Beliefs

As we have seen, Lord Balfour adopted the luminous distinction between the causes and reasons of a belief. The questions involved are therefore partly psychological and partly logical, and the bridge between these two debatable areas is as difficult to cross as that between the immanent and the transcendent. Perhaps because of this very real difficulty, philosophers have never succeeded in analysing the nature of belief very satisfactorily, and as for theologians they have not infrequently shown a tendency to exploit it rather than to explore it. "In view of this theological domination, positive belief has come to seem intrinsically meritorious in the eyes of most people, and disbelief to seem intrinsically wicked, which belief has come to mean specifically *religious* belief. Yet this is plainly only one case of belief, one that can only be appreciated properly in the whole context of our habits of belief."*

A recognized leading authority on the nature of belief is Professor F. C. S. Schiller † whose little book on the *Problems*

* Schiller, *Problems of Belief.*

† Since these words were written, Professor Schiller has passed away. He died at Los Angeles, Aug 7, 1937 *The Times* (obituary notice, Aug. 9) spoke of him as "one of the most productive and also one of the most provocative of Oxford tutors in philosophy."

of Belief is worth reading again and again It is packed full of persuasive and convincing argument, but limitations of space prevent our touching upon it more than very briefly.

Dr. Schiller reminds us that belief is certainly not wholly intellectual, and that its irrational side can never be eradicated by intellectual criticism. Belief is often a composite thing, its parts in conflict with one another. Final and assured belief is rare; at least a shadow of doubt almost always persists and refuses to disappear.

Positive belief and absolute disbelief stand four-square in opposition, pugnaciously facing each other, but between them is "a vast region occupied by the various intensities and shades of belief: half-beliefs, quarter-beliefs, pseudo-beliefs, make-believes, beliefs seasonal, temporary or momentary: 'illogical' beliefs that are 'self-contradictory', and yet do not cancel out and disappear; beliefs inhering in portions of our complex personality other than the dominant or 'normal' self, the 'unworthy' beliefs of our lower nature and the 'ideals' of our aspirations."* This vast region is infected with doubt and is the ordinary region of intellectual debate.

There are many people who never seem to ask themselves how some particular theological dogma, which they have always "believed" to be "true", first found its way into their minds. In all probability the dogma was foisted on them, when they were little children, in the form of words which they were then utterly unable to understand, and has since fructified into a nebulous and incomprehensible idea, an awesome symbol of authoritarianism.

Our actions are very largely determined by our emotions, instincts, intuitions, and cravings; these are primitive and powerful, and are certainly not the products of reason. How often do we *reason* about our loves, our hates, our uncharitable and our hypocritical actions, of most of which we are probably at heart ashamed? All these things thrust reason aside. They are beliefs, but they are not beliefs which are stated and

* *op. cit.*, p. 15.

explicit; they are kept in the dark and are silent; they are implicit.

The beliefs which we *call* our beliefs are those we talk about, write about, boast about, defend and champion, think important, and sometimes profess a willingness to die for. Our trust in their truth is really pathetic. If they were not impregnated with doubt, as they certainly always are, why do politicians and theologians rise in their wrath when their beliefs are attacked? It is because our explicit beliefs are so doubtful that they are so vulnerable. Any debatable belief is believed by some and disbelieved by others. The more a belief is the subject of hot controversy, the more it is likely to flourish; but once it is accepted as a truism it degenerates, "like a politician when he is raised to the peerage."

The important point about debatable beliefs is that, whether they are right or wrong, true or false, they are genuine. They do maintain a practical hold over the mind. Once they lose this hold, and diminish in intensity and influence, they become half-beliefs, and have very little intellectual value. The decline may be due to the disappearance of opposition. Beliefs accepted on authority, and not acquired by honest personal effort, abound in the sphere of religion; they are the natural consequence of the great part played by authority in religion. It should be our paramount duty to test beliefs, and to suspend judgment when more evidence seems attainable. And we should never forget that in coming to a final judgment we are acting only on a balance of probabilities.

From one end of nature to the other, action is the primary fact, and it is an illusion to think that our every act is preceded by some sort of intellectual reflection. Reflection is a late evolutionary development; even so, only the small minority are really capable of it. "Every man conducts by far the greater part of his life without reflection, and *thinks* only when he must." Our idle preference for traditional beliefs is the result of the inertia of habit.

Right down in the very depths of our being, there is always to be found a very human judge, a judge more or less

incapable, more or less prejudiced, but still a judge. Whatever his worth, he interprets appearances and selects and rejects from them, and he is either justified or falsified by the consequences which inevitably follow *

5. The Pursuit of Truth: History

We can afford space for only one illustration of the difficulties involved in the pursuit of truth, and we select that of the historian in his quest for evidence. Most historians follow the maxims of Sir G. C. Lewis (1806–1863) a notable statesman and essayist in the middle of last century. We may summarize his views briefly.

When an historian is recording contemporary events he will be able to rely on his own observations or upon original documents obtained from authentic sources. To an historian not himself cognizant of the events he narrates, the sources of information are mainly the evidence of witnesses, and it is only to the history resting upon the testimony of witnesses that the rules of historical evidence apply.

If we seek to verify any alleged historical fact, we have to ask, (1) does the evidence of the witnesses exist in an authentic shape? and (2) is it true? The first question concerns the accuracy with which the evidence has been transmitted to us, the second the worth of the evidence itself. The means of knowledge of the witnesses, the goodness of their memory, their judgment, their general veracity, their special interests, their personal prejudices, all have to be considered. Unlike a judge, the historian usually has to deal with men long since dead, whose character he therefore has difficulty in ascertaining. The peculiar subject matter of the rules of historical evidence is not therefore the value of the evidence but the accuracy of its transmission.

The supreme canon of historical evidence is that all testimony must be *contemporary*, either received directly, or

* See Schiller, *op. cit.*, more especially the later chapters.

through trustworthy tradition, from contemporaries. "Whenever any event is related in histories written after the time, and not avowedly founded on contemporary testimony, the proper mode of testing its historical credibility is to inquire whether it can be traced up to a contemporary source. If this cannot be done, we must be able to raise a presumption that those who transmitted it to us in writing received it, directly or through a trustworthy tradition, from contemporary testimony. If neither of these conditions can be fulfilled, the event must be considered as incurably uncertain, and beyond the reach of our actual knowledge."

"The rule is universally recognized as *inclusive*; whatever is established by such testimony is credible. There is not, however, the same unanimity in admitting it is *exclusive*: or that whatever is not authenticated by external evidence is uncertain. A stringent application of the rule makes havoc of ancient history, and most historians make an attempt to pick out from the mass of tradition some certain indications of the true course of events. Internal improbability may enable us to doubt or disbelieve an alleged fact; internal probability cannot assure us that the fact was as alleged." *The only decisive evidence is the testimony of credible witnesses.* **Sir George Lewis**, refusing to admit internal consistency or plausibility as a warrant for belief, rejects the accepted history of Rome right down to the war with Pyrrhus.* **Niebuhr**, on the other hand, accepts as solid history the earlier period between the secession of the Plebs and the war with Pyrrhus: our confidence in Niebuhr is thus shaken.

Evidence may be transmitted in two ways: by writing or by oral tradition.

The value of a written record consists mainly in this, that its credibility is not impaired by the mere lapse of time. The only deterioration that a document can suffer from mere lapse of time is the increased difficulty of weighing the credibility of the writer. Yet two doubts may arise even about written records: (1) whether the writing is ascribed to its

* Lewis, *Methods of Politics*, I, p. 27.

real author, and (2) whether it is free from interpolation and mutilation.

Oral tradition loses credit very rapidly with lapse of time. An account of an event, diminishing in evidentiary value at each remove from the original eye-witness, very soon ceases to have any value at all.

Quite evidently the historian has a very difficult task. To discriminate between truth and error in ancient and mediæval records is well-nigh impossible. Consider the historians of even modern times. At the most they can record only a very small selection of events. Can these events ever be truly representative of the whole? *Does the historian show any bias, political, theological, or social in making his selection?* If he does, he is deliberately distorting the truth *

An historian may be perfectly honest but his facts be coloured by his style, by his epithets, by his reasoning, or by his mode of narration. How then can a reader escape the peril of being misled? One writer may make mistakes in names, and dates, and references, and yet have a real substance of truthfulness in him; another may not be wrong in his facts, but have a declamatory, or sophistical, vein in him, certainly to be guarded against; a third may be both inaccurate and untruthful, caring not a jot for facts but wishing merely to write an interesting story. An historical narrative ought to be quite free of the author's personal views, and it should not be overburdened with his reflections, even if these are wise. The historian should have a keen insight into the things he writes about, but in the writing he must be scrupulously impartial.

> "To us, my friend, the times that are gone by
> Are a mysterious book, sealed with seven seals:
> That which you call the spirit of ages past
> Is but, in truth, the spirit of some few authors
> In which those ages are beheld reflected,

* Cf. Lewis, *Methods of Politics*, I, p 270.

With what distortion strange heaven only knows.
History!
Facts dramatized say rather—action—plot—
Sentiment, everything the writer's own,
As it best fits the web-work of his story,
With here and there a solitary fact
Of consequence." *

6. What is Truth?

When Jesus told the Roman Procurator, Pontius Pilate, that he came into the world to bear witness unto the truth, Pilate replied, What *is* truth? But Pilate did not wait for an answer.

It has been well said that the most dangerous of all superstitions is the slavery of the mind to the magical power of abstract nouns.

What, for instance, is *justice*? The law-courts are sometimes quite seriously spoken of as courts of "justice"; the judge does not, however, administer *justice*, but *the law*. The figure of Justice is sometimes made to hold a pair of scales, but what is the *pro* and what the *con* which is put into those scales? Can "justice" be weighed? If so, with what is it counterpoised. Everybody knows, or thinks he knows, what a just judge is: but that abstract stuff called "justice", what is it? It is a word, certainly, but does it convey to the mind a clear and distinct idea? Absolute justice is assuredly an unattainable ideal.

What is *truth*? We do not, of course, use the term in the meaning of the child's simple opposite to a tarradiddle; we refer to its usage by the moralist, the philosopher, and the theologian. Truth has been solemnly defined as "a system of propositions which have an unconditional claim to be recognized as valid"; and again: "truth is a name for all those judgments which we find ourselves under obligation

* Sir Arthur Helps, *History*.

to make by a kind of imperative duty ". Very well; but what do such definitions *mean*? Are we to infer that truth is some sort of theological or philosophical quintessential distillate stored away in a gold box which is kept under lock and key and jealously guarded? The twentieth century has at least cast *that* box away.

The modern philosopher does not live in the clouds as his predecessors did. He has come down to earth, and he keeps himself in close contact with facts. To him *true ideas* are those that he can verify. He realizes that " the truth of an idea is not a stagnant property inherent in it," but that " truth *happens* to an idea; an idea *becomes* true, is *made* true by events."

The absolutely true, that which no further experience will ever alter, is that ideal vanishing-point towards which all our temporary truths are gradually converging. But the converging is asymptotic, and the focus remains at an indefinite and perhaps for ever inaccessible distance. Our experience and our knowledge, and therefore our intuition of the nature of truth, are of necessity far, far greater than those of our ancestors 2000 years back; and they must be, also of necessity, far far less than those of our descendants 20,000 years hence. " Meanwhile we have to live to-day by what truth we can get to-day and be ready to-morrow to call it falsehood." We have thrown overboard Ptolemaic astronomy, Aristotelian logic, Scholastic apriorism, Euclidean space, and a whole host of religious superstitions. All these things were extremely useful during their time, and they correctly represented truth so far as truth was attainable within the limits of experience then reached. Human experience has now " boiled over " those limits, and what our predecessors thought to be true we now know to be false. The past centuries are strewn with the wrecks of systems and theories—philosophical, theological, and scientific; and every one of our systems and theories is bound eventually to suffer the same fate. Truth is bound to evolve as experience grows. To suggest, therefore, that absolute and final truth has already

been discovered, embalmed and enshrined, is to be guilty of wilful dishonesty.

" Truths emerge from facts; but they dip forward into facts again and add to them; which facts again create or reveal new truth, and so on indefinitely. The ' facts ' themselves meanwhile are not *true*; they simply *are*. Truth is the function of the beliefs that start and terminate among them " Truth is continually developing; it is always provisional.

To think that we can distinguish truth from error by reference to some kind of sacred deposit of absolute truth is childish.*

7. The Mind of the Present Younger Generation

By the " younger generation " I mean the well-educated section of younger folk who are thinking for themselves and are bound to take the lead in the future, young people who know something of culture in the deeper sense, who have learnt something of responsibility, who are unsparing in personal effort, and are keen to help to set the world right. I do not refer to the far greater number of uneducated thoughtless youngsters, especially those between 17 and 22, who are out for a perpetual holiday, who have shaken themselves free of every kind of harness, who are self-indulgent, and whose great desire is to be free from self, from thought, from reason, and often from all moral restrictions. These are the victims of all sorts of wild and confusing impressions that storm upon them. How easily their psychology is exploited! How susceptible they are to propaganda! How easily they can be organized, and how violent they may become! For good or for evil, they may prove some day to be a formidable force.

* Cf. Schiller, *op. cit.* Also William James, *The Meaning of Truth.*

But what of their leaders-to-be, the thinking and thoughtful section of young people to whom we have referred? What are they thinking *about*?—Let it be remembered that their minds are essentially receptive, argumentative, logical, analytical, inquiring, truth-seeking. As was pointed out earlier in the book,* this is one of the inevitable results of the highly intelligent teaching of the last twenty years in all grades of secondary schools. And it does not apply exclusively to the boys and girls who have passed on to the various universities. It applies also to the much larger number who leave school at about the age of eighteen, thousands every year. These boys and girls have learnt to despise all intellectual shams and to make themselves unpleasant to those who profess them. Theological ears would burn, could they hear, as I have heard, the scathing † remarks made by these young people about theological infallibility. "Infallibility! What nonsense! Let the theologians provide us with the facts, the *facts*, and we will reason things out for ourselves. Why should we accept opinions already made?"—That may be regrettable, but it is the temper of the present day. *And there is no going back.*

These boys and girls are truly representative of the intelligent modern mind. It is not they but their ageing pre-war seniors who still cherish the childish conceptions of inerrancy and certitude. They are being taught to ask why, and they have been accustomed to be told why, and the day has gone by when the *ipse dixit* of authority can carry much weight with them. Again we say that this may be regrettable, but it is a cardinal fact with which we have to reckon.

The pity of it is that dogma has been illicitly transferred from theological to other studies—economic, political, scientific, ethical, and what not. Dogmatism served its purpose when the masses were ignorant and sleepily receptive, but

* See *Preface*

† Genuinely indignant rather than bitterly sarcastic. Just a little ironical, perhaps

the leading nations are now thinking for themselves, and in these days when dogma and reason engage in battle, the latter is bound in the long run to be the victor.

Future beliefs, political, theological, or others, will be held with a strength exactly proportioned to the weight of evidence, and that evidence must admit of no question.

QUESTIONS

As stated in the Preface, these questions have been suggested by gifted young people known to the author. They are designed to compel the reader to test some of his personal convictions. They are in no way intended to test his acquaintance with the actual subject-matter of the book.

1. In a letter to *The Times*, headed *Quis Custodiet Custodes*, Mr. L. P. Jacks, discussing the League of Nations, asked the question: "Is there any responsible government in Europe or elsewhere willing to involve the people it rules over in the unspeakable risks and horrors of modern warfare at the bidding of a resolution taken by an international council at Geneva in which its own voice is no more than one among many?"—What is the answer?

2. What general inferences concerning possible future wars may be drawn from the following facts?

(α) After the Great War it was officially stated that on the Somme the Allies had attacked in the proportion of nearly 6 to 1, at Loos 7 to 1, and at Neuve Chapelle 25 to 1.

(β) During the Russian army manœuvres on Sept. 19, 1936, 1200 Soviet parachutes with machine-guns and ammunition landed behind the enemy lines and captured an aerodrome near Minsk (see Plate IV.).

(γ) During the last few years, our popular Press and voices in Parliament have, by their violent attacks, deeply wounded certain powerful foreign nations with long memories, all of them now our near neighbours, even Japan being only four days away.

3. Many people believe that the Utopias they desire can be reached by a change in political systems. Examine this belief in the light of the history of civilization. Is the belief rational or is it irrational? How is mankind first to effect a change in its own heart and free itself from envy, hatred, malice, and all uncharitableness,

which alone can make a Utopia possible? Is the attitude of the Christian churches towards all who do not share their particular views conducive to such a change?

4. Select a dozen members of the House of Commons, half of them known to have received a Public School and University education, the other half known to have received only a Public Elementary School education. Ignoring their own special political points of view and all personal matters, what essential differences do you observe in their constructive criticisms, in their acumen, in their ability to cope with sudden emergencies, and in their ability to win the ear of the House? In what respects do the first group seem to have benefited from their earlier advantages? From the point of view of value to the nation, is there any *material* difference? Do you notice, for instance, any difference in the matter of objective judgment, in the control of soft sentimentality, in a willingness to listen seriously to other points of view, in a willingness to vote according to the weight of the arguments brought forward? If not, what in your opinion are the special advantages of higher education?

5. The dictator breaks heads, the democrat counts them. Which system of government do you prefer? Is your preference the result of reasoned conviction, is it merely an obsession, or is it tinged with doubt? Set out the advantages and disadvantages of each system. How do you explain that different people, arguing from the same basic facts, arrive at different conclusions? Do you ever impugn the honesty of those who disagree with you? if so, why?

6. Napoleon was a Corsican, not a Frenchman, which may partly explain why he pursued such a ruthless vendetta towards England. Did he ever truly represent the French people? Is the dictatorial rule of a single person compatible with democracy? Can it be said that Lenin, Mussolini and Hitler became dictators as the result of a reasoned urge from above, or of an unreasoned mass-drive from below, or were they personally powerful enough to impose their wills on the peoples they represent? In what respect can it be said that they do truly represent the peoples?

7. Professor Hearnshaw says (*Political Ideas*, p. 140) that Lenin, Mussolini, and Hitler all "overthrew corrupt and incompetent Democracies and established ruthless but efficient Dictatorships". No one would say that the remaining great Democracies of Europe

PLATE IV

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FLIGHT OF RUSSIAN PARACHUTES

Facing p. 504

are corrupt, but can it be said that they are competent? What do you *mean* by competent?

8. It has been said that Communism and Fascism tend to transform human existence into the soulless mechanisms of the bee-hive and the ant-hill; the State is everything, the individual nothing. We may grant that bees and ants are extraordinarily efficient though not much more than efficient machines. Is the suppression of the individual in human society likely to benefit humanity? Set out the arguments *pro* and *con*.

9. The "ideologies" (Communism, Fascism, &c.) which are now competing for the allegiance of man have borrowed some of the less attractive traits of institutional religion, e g. its intolerance, its appeal to emotion at the expense of reason, its reliance on propaganda rather than persuasion. These ideologies are, in fact, virtually secular religions, to which millions of men are absolutely devoted. If the faith of these men is in a cause which they deem to be righteous, rather than in a Church or in a man, can orthodox religion rightfully assail them?

10. Professor Flinders Petrie has pointed out that democracy has been the last phase of every great civilization; that each civilization has lasted about 1800 years, an autocracy being succeeded by an oligarchy, and this by a democracy in which some form of socialism has eaten up the accumulated wealth of previous centuries, idleness and decay setting in, and people of greater vitality taking possession. Thus socialism is no more a political novelty than it is a political disease; it seems to be just an ordinary phase of inevitable evolutionary development—regulative, static, uniformitarian, with a tendency to gradual fossilization.—Are there any new factors in Western European civilization—for instance, the new dictatorships—which may save it from the fate of all its predecessors?

11. Which is doing the greater harm—the propaganda of the free Press in democratic states, or that of the controlled Press in the totalitarian states?

12. An angry publicist has said, "the propaganda-moulded mass-mentality which is being fostered in all countries, democratic and autocratic alike, will in the end kill all creative activity and thereby all possibility of progress."—Is the popular Press really gradually lowering the intelligence of the half-educated people it caters for?

and is broadcasting really acting as a general opiate, as is so often maintained? If so, what are the remedies?

13. Ruskin propounded this riddle: "Distribute the earth as you will, the principal question remains inexorable.—Who is to dig it? Which of us, in brief word, is to do the hard and dirty work for the rest and for what pay? Who is to do the pleasant and clean work and for what pay? Who is to do no work and for what pay?"—Compare the solutions put forward by different political schools of thought: which do you prefer? on what grounds?

14. If evolution is a fact, as is now generally agreed, some sort of civilization probably began to emerge about 10,000 years ago. Man then differed but little from the beasts around him. During the 10,000 years, some progress has of course been made, but man has certainly preserved his instincts as a fighting animal, and his hideous savagery in modern warfare suggests that he is not yet very far removed from the brutes. Can the term "civilization" be appropriately used to describe the present stage and state of humanity, except in a polite sense? If evolution signifies progress, is not the world likely to become much more civilized and Christian 100,000 years hence than it is now? How will our far-off successors of those days be likely to describe us?

15. All philosophy, theology, and science must start off with the *given* (data), which may be arranged in such a way that at one end we have the clearly given which seem to admit of no doubt at all, and at the other end a region of haze which is full of doubt and uncertainty. Obviously, we must cut out the latter from all serious consideration, but where is the line to be drawn? Can doubt be eliminated entirely? If not, how are we to distinguish (*a*) between the certain and the uncertain, (*b*) between faith and credulity?

16. Set out points of difference of connotation in the two terms "faith" and "credulity".

17. The terms *agnosticism*, *scepticism*, and *rationalism* are all quite inoffensive, the first being an ordinary negative term implying "I do not know", the second implying "I feel doubtful", the third maintaining the supremacy of the human reason. But militant religion has long ago deliberately modified their connotation, and has made them cudgels with which to belabour its opponents: what is its motives? If a man does not know, if he feels doubtful, or if his reason compels him to refuse assent to a particular hypo-

thesis, which is the more immoral—to say so honestly, or to take refuge in a denial?

18. "The scepticism of the younger generation has not been inherited from their elders." Then what is its origin?

19. As a rational being, man naturally desires to know the universe as a single harmonious system, and this is the real motive power of all science and all philosophy. To what extent can it be regarded as the motive power of theology also? Can logic and faith function together as equal partners? Can reasoning always safely be reduced to ratiocination?

20. The reconstituted Pontifical Academy of Sciences was inaugurated by the Pope on his eightieth birthday, 1937. This Senate consists of 70 members, drawn from all parts of the world, and not confined to Roman Catholics. The three British members are Lord Rutherford, Sir Charles Sherrington, and Professor E. T. Whittaker of Edinburgh, only the last-named being a Roman Catholic. All 70 are eminent men of science. Some Roman Catholics are gravely perturbed, inasmuch as their Church hitherto has vigorously opposed the march of science. How would you reassure them?

21. Cicero (*De Offic.*) quotes Ennius as saying, "Quem metuunt, odere: quem quisque odit, periisse expetit", and he adds, "Multorum autem odiis nullas opes posse obsistere nuper est cognitum."—It is of profound psychological interest that men who are greatly feared are greatly hated. Is there any satisfactory explanation?

22. The most debilitating of all the human instincts is fear, and the Christian churches have always tended to exploit it. What could have been their motive?

23. Christian morality holds out the hope of heaven and the threat of hell as the appointed and appropriate incentives to a virtuous life. To what extent is a life a necessarily selfish life if it is devoted to the avoidance of future personal punishment and to the obtaining of future personal reward?

24. The great Christian doctrine that service rendered to others is the most certain source of one's own satisfaction and happiness is an ethical principle which every democracy professes to teach to its children. But is this teaching more obvious in existing democratic states than in the totalitarian states?

25. The maxims and precepts contained in the New Testament

collectively constitute the doctrines of Christianity. But if a professing Christian scrupulously adopts these doctrines as his standard of personal conduct, is he a good Churchman? Is a loyal Churchman a good Christian?

26. It has been the custom of Christian churches to enclose themselves in a ring fence, to urge that Christianity is unique, and to maintain that the rest of the world is "heathen" and "backward". But the fence has been very largely broken down as the result of the study of comparative religion and of oriental mysticism and philosophy. Would you say that in the eyes of God the lives of Asiatics are less worthy, and really less "Christian" in the literal sense, than the lives of Europeans and Americans? If yes, how does your answer square with the fact that Jesus Himself was an Asiatic?

27. What is the distinction between a *crime* and a *sin*? Is it necessary for Church and State to use different terms for wrongdoing? Is a criminal necessarily a sinner? Is a sinner necessarily a criminal?

28. A man shot his wife dead to prevent her from falling into the hands of a horde of revolutionary ruffians engaged in wholesale outrage and murder. Did he commit a crime? Did he commit a sin?

29. During the year 1937 events occurred which revived the question of the remarriage of divorced persons. It was quite clear from correspondence in *The Times* that the statement so often made that our Lord laid down the principle of the indissolubility of marriage is open to such serious doubt that it certainly ought not to be maintained.—A woman, discovering that her husband had led a foul life before marriage and was leading a foul life still, divorced him, and a year or two later married again and happily. Presenting herself at the Lord's table she was repelled by the officiating priest and told she was a "sinner", inasmuch as she was living in adultery, her first husband still being alive. Our Lord himself would certainly have been the last to repel a sinner from His own table. But *was* the woman a sinner? What treatment would you mete out to the priest? merely refer him to 1 Cor. xiii.? Or would you suggest to him a remedy for pharisaism?

30. A large and rapidly increasing number of educated people are turning away from official forms of religion and are adopting an introspective quietist form, preferring to commune with God

privately. Although they do not go to Church and do not subscribe to any creed, they are deeply religious and are devout Christians. Are such people open to criticism? If so, why?

31. It was Coleridge who said, " God will never reject a soul that sincerely loves Him." If Coleridge referred to non-Churchmen as well as Churchmen, would you agree? Would any Church agree?

32. Read the following verses by a former well-known American writer, Ella Wheeler Wilcox (1855–1919), which were labelled " Heresy ". First attack and then defend, setting out your respective reasons in parallel. Which scale is the more heavily weighted? Do you feel you have been quite fair (a) to Christians, (β) to the Christian Churches?

Nothing within me responds to the story of Adam and Eve:
And Genesis seems like a tale not meant for the world to believe:
Yet when I wake in the dawn, if the skies are gray or gold,
The love, the love in the heart of me, for God, can never be told.

Jesus to me is a man who lived the life divine:
And I think of his birth as a human birth, just like yours and mine!
But the love down deep in my heart, that is sweeter than any other,
Is the great uplifting, tender love I give to Christ, my brother

The world has a thousand creeds, and never a one have I:
Nor church of my own, though a million spires are pointing the way on high.
But I float on the bosom of faith, that bears me along like a river:
And the lamp of my soul is alight with love, for life, and the world, and the Giver.

I know how brief is my span, and I know how certain is death;
And I send out a prayer of love and trust with the breathing of every breath;
And heretic though I am, outside of the pale of creeds,
I have love in my heart for God and man: and I think it is all one needs.

33. The genus " English gentleman " has been defined as " conservative, respectful of tradition, individualist, unassuming; in fact

anxious to appear ordinary and to make no pretensions of being better than the next man of his own class; polite to inferiors while perfectly conscious of their inferiority; distrustful of display; insular; speaks of ' scholars ' (those who are acquainted with Latin and Greek) with respect, but of the ' learned ' (those whose knowledge lies in other directions) a little patronizingly; has always been to a Public School; has a pedigree." Can this type be improved upon? If so, how? Is the type open to criticism? If so, how?

34. Feudalism has broken down, but the English gentleman has survived. Will he survive the consequences of the economic reconstruction so rapidly taking place all over the world?

35. Is a member of the British House of Commons really representative of his Party, or of his constituency, or of his country, or of his convictions, or of his obsessions?

36. If, as Eugenics suggests, children were limited to selected strains of human stock, the strains being selected impartially for physical, intellectual, and moral excellence, without regard to colour or nationality, there would, presumably, be ultimately not only a fusion of all nationalities, but a vastly improved human race. Is there any other way of bringing about such fusion? Are the forces operating against it anything more than prejudice?

37. The 87-year-old Bishop Heard, representing the African Church at the World Conference on *Faith and Order* at Edinburgh in August, 1937, was refused admission to an hotel because of his colour. It is true that both the Archbishop of York and the Chancellor of the Exchequer promptly offered him hospitality, but what is likely to be the effect of the ban amongst the coloured peoples of the Empire?

38. Every year the problems of Government become more and more complex and public opinion more emotional and unstable. Is democracy likely to be able to cope with the difficulties that will inevitably arise? Will it dare to impose upon itself a discipline sufficiently stern to meet the needs of the case? If not, what alternative course would you advise?

39. Every new religion has created a separatist and antagonistic society. Inasmuch as religion has thus divided mankind acutely, inasmuch as religious intolerance is the most bitter kind of intolerance, inasmuch as religious fanaticism is the most deadly kind of

fanaticism, is there any force in religion which can make for human unity?

40. If the Christian religion has failed to promote the highest human welfare and to be an effective unifying agent in those parts of the world where it is practised, what is the real value of missionizing propagandist effort on its behalf in other countries?

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